American Aviation

Engineering & Development Issue

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AIRTRENDS Washington, D. C., Oct. 25, 1954

GREATEST SINGLE FACTOR in the mushrooming stature of the missile has been progress with atomic and hydrogen warheads. Availability of progressively smaller weapons of both types has made the missile the logical carrier, whether used intercontinentally or lobbed across the front lines.

Eventually it may be possible to develop a missile warhead which can be installed at the factory, shipped, and stored simply and safely. Prior to use, a fuse would be inserted in the warhead which would serve to arm it.

DEMANDS OF THE INTERCONTINENTAL missile may yet prove the greatest impetus to development of a nuclear-powered aircraft engine. The power required to propel a 5000-mile-range missile at Mach 15, a speed frequently used in reference to this type missile, is strikingly similar to that of efficient nuclear powerplant proposals.

Many of the atomic engine's limitations are minimized by this type application.

Such applications are not "around the corner." Persons close to atomic engine development claim such applications depend on a whole new concept of utilizing atomic power, one based on direct use of the reactor heat rather than conversion of reactor heat to power via conventional turbine engines, as generally visualized.

INCREASED ENGINE POWER may be the answer to the "thermal barrier." Present concepts of structural problems brought on by aerodynamic heating at high speed assume the use of conventional light alloys or the newer "exotic" metals. Availability of efficient high-thrust engines could justify the use of steel alloys with adequate strength at elevated temperatures.

VIRTUALLY EVERY GYRO manufacturer in the country is involved in some aspect of developing inertial navigation equipment for the guided missile program. Inertial guidance systems, virtually free from the problems of jamming or related accuracy shortcomings, have been used successfully in cross-country military aircraft flights.

OVERLOOKED IN THE SWIFT STREAM of missile developments is the tremendous effect that technological advances being made in this field will have on other branches of aviation. Low electronic reliability, for instance, has long been the stumbling block to full-scale all-weather flying. Missile demands have brought about great advances which were economically impossible for other phases of the industry to support.

NEWS at DEADLINE

DC-7D Report Confirmed—Confirmation of BOAC's interest in the Douglas DC-7D (p. 22) has come from the airline and Douglas. BOAC said: "We are informally discussing the potentialities of a proposed DC-7 . . . equipped with a powerful new British turbo-propeller engine produced by Rolls-Royce."

Douglas Aircraft said: "Informal discussions of a highly satisfactory nature have been held with several leading European airlines including BOAC." It also disclosed that the RB109-powered DC-7D has been discussed with operators in the U. S. and other parts of the world.

Boeing Gets $300 Million in Orders For Advanced B-52D's

Boeing Airplane Co. has received contracts totalling more than $300 million for production of the advanced B-52D heavy jet bomber version.

Boeing-Seattle received $233,166,000 for B-52D airplanes, spare parts, and special tools. Quantity of B-52's was listed as 50.

Boeing-Wichita was awarded $83 million for B-52D's and spare parts.

Other big AF contract awards include:

$34 million to Allison Div. for 275 J71-A-9 turbojet engines;

$30 million to Lockheed-Marietta for airplanes (apparently C-130's), spare parts, training tools, and ground handling equipment;

$22.2 million to Ford Motor Co., Chicago, for 60 J57-F-13 turbojet engines.

Urge Small Plant Development

Small Defense Industries Association (SDIA), comprising some 50 companies in the Los Angeles area, has proposed an industry-government coordinating committee to promote a system of defense procurement and mobilization planning to encourage and develop production capabilities of small, privately financed defense plants. The committee would include the Office of Defense Mobilization, Air Force, Navy, Army, Commerce Department, Aircraft Industries Association, and SDIA.

Cutbacks in aircraft procurement have been seriously reflected among subcontractors in the small business category, SDIA said.

Meanwhile, Merle J. Davis, president of Aircraft Parts Manufacturing Association in Los Angeles, has urged that 20 or 25% of each defense dollar in contractural work be mandatorily allotted to small business firms.

7 New Freighters For AA

American Airlines has announced the $10.4 million purchase of seven additional Douglas DC-6A airfreighters. Contract with Douglas calls for delivery of three airplanes in May, two in June, and two in July 1956. In its first decade of scheduled freight operation, American reported a $60 million income.

Carriers May Buy AF C-46's

Surplus Air Force C-46F transports on lease to airlines have been offered for sale to lessees, but if the carriers do not want to buy them the AF will continue to lease them. Most leases expire December 31.

Putnam Quits Delta

Carleton Putnam has resigned as board chairman of Delta-C&S Air Lines, a post he's held since the merger in May 1, 1953. He will continue indefinitely as a director, however. He said he plans to devote his time to literary work.

He announced the resignation by stating that he would not be a candidate for reelection at the annual meeting in Monroe, La., held this week.

Titanium Output Up

Rated output of titanian sponge has been reached by the Titanium Metals Corp. of America, which is now producing 3600 tons per year at its Henderson, Nev. plant. The other major producer, du Pont, is due to reach 3600 tons in 1955. Battelle Memorial Institute of Columbus, O., will conduct R&D work on titanium under an 18-month $1 million Defense Department contract and will offer customer service to firms using the metal.

Borg-Warner Acquires Weston

Borg-Warner Corp. has acquired Weston Hydaulics Ltd., west coast manufacturer of aircraft hydraulic and pneumatic equipment, by an exchange of stock. Weston will function as a subsidiary and will remain under the same management which has directed it since it was founded in 1945.

Traffic Increase Predicted

A moderate increase in passenger traffic and an even more moderate increase in earnings are predicted for domestic trunklines in the near future by Standard & Poors. Net earnings in 1954 are expected to fall below 1953's $48 million. S&P noted a generally favorable view of the overall financial picture: "Good stockholder equity is being developed, the industry's outlook is promising, and selected stocks of the group are considered well worth holding on a long-term basis."

To Modify All Neptunes

Lockheed's Burbank plant has received a $9 million Navy contract to modify all existing Wright Turbo Compound-powered P2V-5 and P2V-6 Neptunes to take Westinghouse J34 jet pods as well. Lockheed will also install most of the 3400-pound-thrust engine pods but some installation work will be handled by Navy bases around the world.

Latest version of the Neptune, the P2V-7, already has the two piston/two jet configuration.

Kaiser Leases Plant

Kaiser Aluminum & Chemical Corp. will operate a government-owned aluminum aircraft forging plant at Erie, Pa., replacing Willys Motors Corp. The lease will run for 20 years. Willys has operated the $9.5 million plant since it was reopened in 1951.

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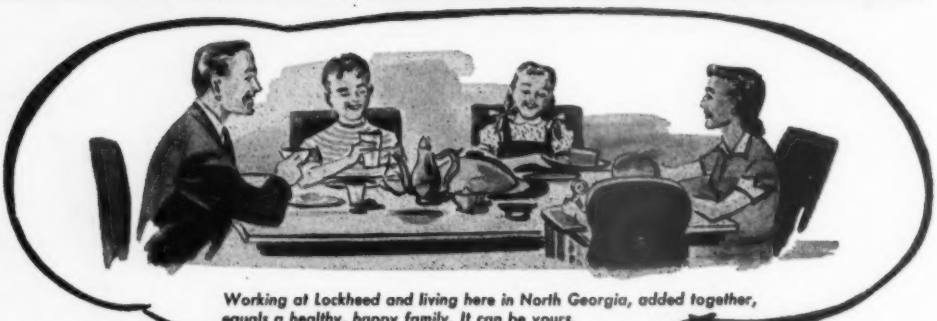

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Letters

Letters should be addressed to The Editor, AMERICAN AVIATION *Magazine, 1025 Vermont Ave., N. W., Washington 5, D. C. Anonymous letters will not be printed, but names will be withheld upon request.*

News on the Plus Side

To the Editor:

Re your editorial in the September 27 issue on lagging interest of youth in aviation:

When the picture looks bad everyone enjoys some news on the plus side.

Here at Stephens College we have the greatest number of students in aviation this year that we have had in the last seven years. Last year alone our enrollment increased by 33⅓% over the previous year. Some of my friends at other colleges and universities report a similar picture.

Of course, there just are not enough colleges and universities—or high schools—offering courses in aviation. If many of our schools would wake up to their responsibility for modernizing their curriculum, CAA's Wiley Wright might have a much better picture to paint in another five years.

Wiley might have mentioned the 45,000 CAP cadets who are trying desperately to get into aviation and often get only a kick in the teeth for their efforts.

Your magazine is still a must in our courses.

KENNETH E. NEWLAND
Head of Aviation Department
Stephens College
Columbia, Missouri

Lucrezia Baccio del Fede

To the Editor:

I am student of aeronautics and I like traveling as much as aviation matters.

Lacking time and money, I cannot travel much, but your *En Route* is always interesting and makes me work harder to get later what I cannot have now.

Every other week I go to the American library (I must thank you Americans for your facilities here that enable me to read books and magazines that otherwise I could not read) and read every word in AMERICAN AVIATION magazine. It fits my wishes better than any other magazine because it speaks about aviation, art, and travel altogether.

But this letter is about a theme that surely invites one to dream; a theme that you have treated on in your October 12 (1953) issue. It is about Lucrezia Baccio del Fede.

Some days ago I went to the Prado Museum to look at Lucrezia. She is beautiful and the picture is wonderful indeed. I think that every man would be crazy about her, at least during her life.

Your fine writing about her left my imagination wandering; and it was easy for me to find out the following things:

Lucrezia Baccio del Fede was the wife of a hatter named Carlo Recanati when Andrea del Sarto knew her and fell in love with her. The hatter died and then Andrea and Lucrezia were married in 1517. Later she became

Andrea's widow and survived him 40 years.

You said that Andrea del Sarto painted Lucrezia as a "demure" madonna, but Vasari (a pupil of A. del Sarto) said that she was faithless, overbearing, jealous.

About her house I can say this:

Andrea went in 1518 to Paris, invited by Francis I, to paint for the court, but Lucrezia urged his return to Italy. Francis I asked him to come back soon and gave him a sum of money to purchase some works of art for the court of France. However, he spent that money in building a house for himself in Florence.

And that is the answer to some of your questions. I am afraid I am doing a mistake in writing this story because sometimes science kills imagination and imagination is finer than science.

AMABLE LINAN MARTINEZ
Don Ramon de la Cruz 67,
Madrid, Spain

Perhaps the moral about Lucrezia is: never trust a woman.—Ed.

Accident Prevention

To the Editor:

AMERICAN AVIATION'S *Extra Section* has been one of my favorite columns since you initiated it. Therefore, you can well imagine my pleasure when I saw the September 27 issue contribution by our good friend, Jack O'Donnell.

Jack is one of the stalwarts and, to quote his own terminology, "graybeards" of the National Safety Council's Air Transport Section, as well as other accident prevention and fire prevention organizations.

You further enhance the value of your magazine to industry each time you publicize accident prevention activity.

HOWARD WARZYN
Staff Representative
National Safety Council
Chicago, Illinois

No Lack of Interest

To the Editor:

With respect to your editorial, "Declines Don't Add Up," in the September 27th issue of AMERICAN AVIATION, it is our impression in this Department that the big difficulty is the adult attitude rather than the youth attitude toward civil aviation which has resulted in the declines.

Anyone who has taken the trouble to test the attitude of youngsters from the kindergarten up through grade school will testify that the interest and enthusiasm for anything relating to aviation is boundless in these groups.

Among the teen-agers there is a guarded interest and enthusiasm which is tinged with scepticism. This attitude, we believe, reflects an adult attitude which has permeated a large segment of our legislative bodies, the Department of Commerce, the CAA, the CAB, and even our trade journals for the past seven or eight years.

Wiley Wright's figures are correct with respect to every item excepting the reported decline in the number of fixed-base operators. This is not a correct report insofar as the State of


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Minnesota is concerned. In this state, the number of commercial operations on our outlying airports has been increasing and we have at this very moment a half-dozen or more potential operators seeking to find locations on some of our presently uninhabited airports. If this trend persists, in our state we will, within the next eight or 10 months, have not only restored commercial operations to every airport where these operations were abandoned following the decline in G. I. training, but will have added somewhere between eight and 10 new operations on airports and at cities where no such operations have previously existed. This is a most encouraging sign.

Mr. Wright's Aviation Incentive Movement in itself is not the answer to the problem of capturing the enthusiasm and imagination and drive of youth for the many requirements of the aviation industry. It should be noted that the real problem is not one of stimulating interest and enthusiasm of our youth since it already exists, but rather one of capturing and guiding it through the critical adolescent period. The Aviation Incentive Movement will encounter exactly the same barrier as did the G. I. training.

What indeed can youth do with the interest and enthusiasm and skill once it has been acquired? Nationwide we have lost interest only on major air terminals where even a distant view of aviation's activities is guarded by a turnstile. In the airframe industry, we concentrate on the production of aircraft for the user who is to fly 400 hours or more per year and we provide nothing for the user who flies 200 hours or less per year. In our national aviation policy commitments, we have more or less scorned the so-called "private flyer" and the multiple number of low-cost community airports required for their use and, more than that, we tend to surround him with more and more restrictions and limitations.

As with the G. I. training program, it is going to be extremely futile to expend time and effort stimulating aviation youth interest and developing skills if after being acquired they cannot be used.

Today the personal aircraft industry is not producing enough airplanes to take care of normal attrition and the airframe industry has frankly estimated that the total civil aviation active fleet will sharply decline in population in the next five years. Yet the demand for used aircraft is so strong that the "boneyard" has long since vanished from our airports and anything that can be repaired and made to fly has been rebuilt and sold to an active market at premium prices.

Mr. Wright's Aviation Incentive Movement undoubtedly is a desirable thing, but along with it is needed an Adult Indoctrination Movement.

Incidentally, the State of Minnesota, along with some other states, is continuing to build the low-cost small-community "grass root" airports which will be a very handy thing indeed if Mr. Wright's program is productive of results.

L. L. SCHROEDER
Commissioner

State of Minnesota
Department of Aeronautics

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American Aviation World-Wide Directory: Twice-yearly listing of products, people, and organizations. $7.50 each. Managing Editor—Marion E. Grambow.

Official Airline Guide: Monthly publication of airline schedules and fares. $13.50 per year in USA; $14.00 in Canada; $15.00 elsewhere. Published from 139 N. Clark St., Chicago 2, Ill. Phone: Central 6-5804. Managing Editor—Robert Parrish.

Air Traffic News (Incorporating Air Traffic Digest): Daily rates and tariff news. $175 per year. Managing Editor—Wallace I. Longstreth.

Airports: Weekly newsletter for airport officials, suppliers, and services. Airmailed every Friday. $25 per year. Managing Editor—Lois C. Philmus.

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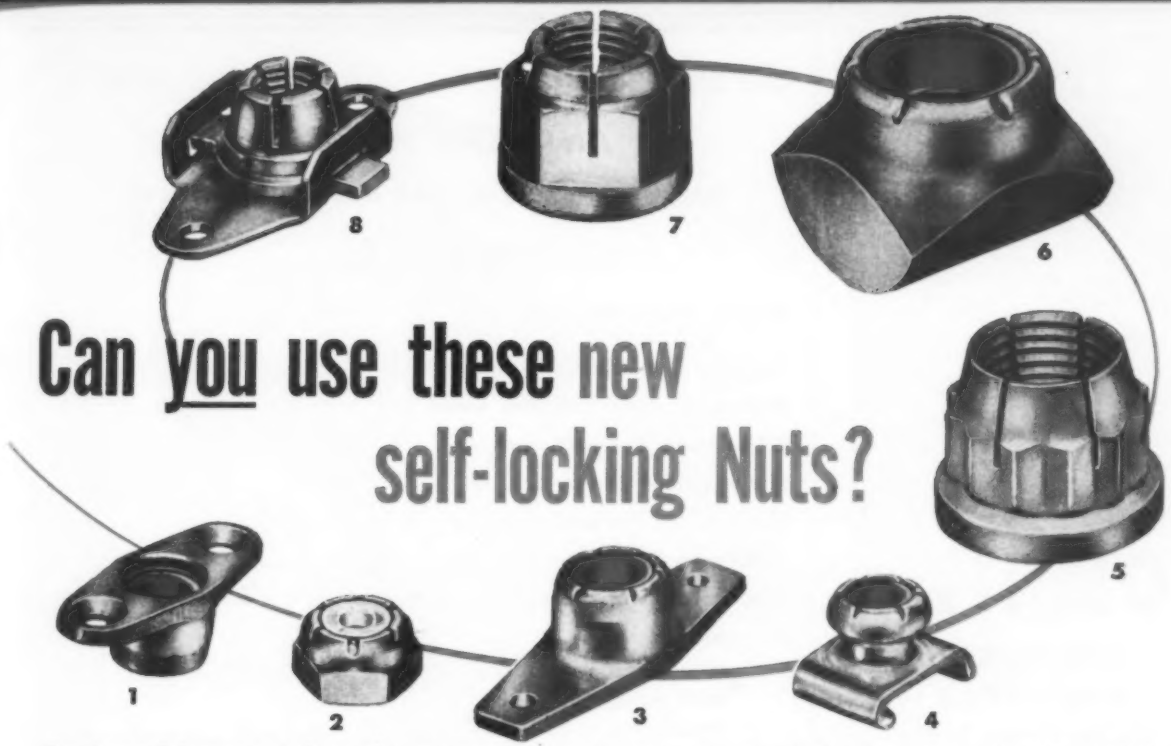

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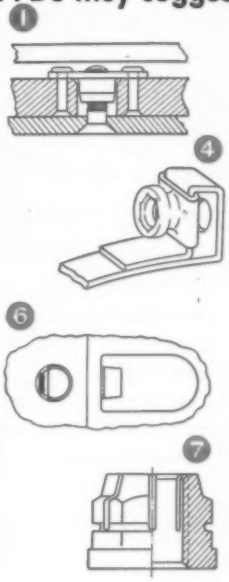

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When & Where

Oct. 23-24—Air Mail Pioneers, Central Div., annual reunion, VFW Club, Elmhurst, Ill.

Oct. 27—ATA airport passenger terminal service committee mtg., New York City.

Oct. 27-29—Southeastern Airport Managers Assn., Cavalier Club, Virginia Beach, Va.

Oct. 27-29—National Business Aircraft Assn. mtg., Hotel Adolphus, Dallas, Tex.

Oct. 28-29—Aircraft Electrical Society, 11th annual display mtg., Pan Pacific Auditorium, Los Angeles.

Nov. 2-3—ATA committee on rotorcraft mtg., Washington, D. C.

Nov. 2-4—ATA stores and material planning committee mtg., Atlanta.

Nov. 2-19—Eighth Air Transportation Institute, American University, Washington, D. C.

Nov. 3-4—Transport Aircraft Hydraulic Conference (sponsored by Vickers, Inc.), Park Shelton Hotel, Detroit.

Nov. 4-5—Airborne and Navigational Electronics, east coast conference, Sheraton-Belvedere Hotel, Baltimore.

Nov. 4-5—Illuminating Eng. Society, aviation light committee, technical conference, Williamsburg, Va.

Nov. 8-9—National Air Taxi Conference, annual mtg., Biltmore Terrace Hotel, Miami Beach, Fla.

Nov. 8-10—National Aviation Trades Assn. annual convention, Biltmore Terrace Hotel, Miami Beach, Fla.

Nov. 9-12—Air Line Pilots Assn., convention, Sheraton Hotel, Chicago.

Nov. 11-12—Air Mail Pioneers, Western Div., annual reunion, Hollywood Roosevelt Hotel, Los Angeles.

Nov. 12-13—National Symposium on Quality Control and Reliability in Electronics, Statler Hotel, New York City.

Nov. 14-17—Aviation Distributors and Manufacturers Assn., 12th annual mtg., Mayflower Hotel, Washington, D. C.

Nov. 15-16—Air Traffic Conference mtg., Waldorf Astoria, New York City.

Nov. 17-19—California Assn. of Airport Executives semi-annual mtg., Claire Hotel, San Jose, Calif.

Nov. 18-19—American Society for Quality Control, ninth Midwest Conference, Baker Hotel, Dallas, Tex.

Nov. 18-19—Airport Operators Council, mid-year board of directors mtg., Park Plaza Hotel, St. Louis.

Nov. 29-Dec. 3—American Society of Mechanical Engineers annual mtg., New York City.

Nov. 30-Dec. 3—American Rocket Society, ninth annual mtg., Hotel McAlpin, New York City.

Mar. 28-Apr. 1—Ninth Western Metal Exposition, Pan-Pacific Auditorium, Los Angeles.

International

Nov. 8-10—Air Industries and Transport Assn. of Canada, annual mtg., Chateau Frontenac, Quebec City.

Nov. 10-13—International Air Transport Association helicopter committee mtg., Montreal.

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Industry Spotlight

• Some of the new long-range missiles currently under discussion will be facing far more of the "thermal barrier" problem than any manned aircraft presently conceived. Unlike the sound barrier, which was solved by the X-1 (i.e., once a plane is through it there is no longer a problem), the outside temperatures keep intensifying.

• Optimum goal as far as missile planners are concerned would be to have the powerplants, whether turbojet, ramjet, rocket, etc., cost no more than 20% of the total missile. Thus far, price has ranged from as low as 18% to more than 80%.

• Despite the fact that the three services began fiscal 1955 with nearly $1.2 billion available for ordering missiles, it still has not been decided which service will obligate what money and for which missile types. Civilian politcal considerations are said to be involved.

• One of the biggest missile problems facing the military (and to a lesser extent the manufacturing companies) is getting the "birds" to a point where ordinary GI's can fire them without difficulty. Company engineers and technicians are now launching missiles with little trouble, but ordinary troops have not been quite so successful.

Philco Corp.'s recent $150,000 contract from the Navy Bureau of Ordnance for the Sidewinder missile indicates that there are now three types of air-to-air missiles (eight variations) scheduled for the Navy and USAF. Ordered into production are three types of Hughes Falcons for the AF, three Sperry-Douglas-Raytheon Sparrows for the Bureau of Aeronautics, and two Sidewinders for BuOrd.

• Interservice coordination on the missile program to prevent unnecessary duplication has enabled each service to concentrate on its own bailiwick. But at least two surface-to-air missiles, the Bendix Talos and Convair Terrier, are to be used by other services. Both are Navy missiles, but the Terrier will also go to the Army and Marine Corps. And one version of the Talos will be evaluated by the USAF.

• Missile ordering over the last four years has been almost five per cent of what the three services have been buying in aircraft. Between fiscal 1951 and 1954, Defense placed orders for $35.9 billion worth of planes and $1.9 billion worth of missiles. Aircraft obligations, beginning in 1951, were $8.6, $13.1, $11.7, and $2.5 billion. During the same years, missile obligations were $275, $601, $383, and $634 million.

• Nuclear-powered missile is now considered not only feasible but practical as well. Pentagon officials had hesitated about sponsoring such a development because of the tremendous cost involved. Advent of hydrogen warheads and the resultant large-scale destruction have convinced them that a nuclear missile would be cheaper for the purpose than manned bombers.

• Aircraft firms are growing increasingly worried about the competition they are receiving from universities and non-profit organizations in trying to obtain military research contracts on missiles. A slightly lesser worry involves research carried on by military laboratories. It's possible congressional action will be sought.

• Forthcoming Anglo-American agreement on exchange of missile information will provide Britain, at the very least, with information on where U.S. companies have gone wrong in the past so that the British will not waste time with similar approaches. It has not yet been decided how far the U.S. will go in furnishing its own missiles so that the British can test them.

COMPRESSING TIME

In any security program *time* is the one irreplaceable element. Making the most of time is particularly vital in guided missiles projects. Fairchild's Guided Missiles Division has demonstrated its ability to "spend" time effectively. Its completely integrated engineering and production organization can, in effect, *compress time.*

With a balanced engineering team and an experienced production staff housed together in a facility built specifically for the development and manufacture of missiles, Fairchild can cut down lags in moving a missile project from the design and development phase into the production phase.

It *has* done so.

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Guided Missiles Division

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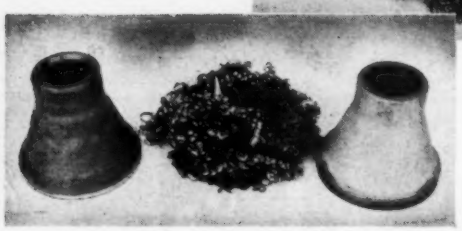
Speed Control Division, Wickliffe, Ohio • Stratos Division, Bay Shore, N.Y.

THE U. S. NAVY BUREAU OF AERONAUTICS, AND INDUSTRY, COMBINE TO ACHIEVE . . .

Reduced Cost and Improved Producibility for

ROCKET POWER PLANTS



The time and material savings for this one JATO part are illustrated by the "before" (above) and "after" (left) photographs.

The U. S. Navy Bureau of Aeronautics has achieved impressive savings for the government and assured availability of rocket powerplants during emergencies by conducting at Aerojet-General a production engineering program resulting in reduced cost, elimination of strategic materials and facilities, and simplification of manufacturing processes. This program, directed primarily toward the new 15KS-1000 smokeless JATO, has been a significant part of Aerojet-General's effort to maintain high standards of quality and reliability while, at the same time, reducing costs and greatly expanding its production capacity to meet anticipated Department of Defense requirements.

• SOLID- AND LIQUID-PROPELLANT ROCKET POWERPLANTS FOR MISSILE AND AIRCRAFT APPLICATIONS • THRUST REVERSERS (SNECMA) • AUXILIARY POWER UNITS AND GAS GENERATORS • ELECTRONICS AND GUIDANCE • ORDNANCE ROCKETS • EXPLOSIVE ORDNANCE AND WARHEADS • UNDERWATER PROPULSION DEVICES • ARCHITECT-ENGINEER SERVICES FOR TEST FACILITIES

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ESTABLISHED JUNE 1, 1937

World's Largest Aviation Publishers
American Aviation

VOL. 18, NO. 11

BUSINESS

New Nike Contracts Total $200 Million; Philco Building Sidewinder

MISSILE SPENDING made financial news as new contracts were awarded on the well-publicized anti-aircraft weapon, the Nike, and on the security-cloaked air-to-air Sidewinder.

Continuation of Nike production at Western Electric and Douglas Aircraft Co. plants at Los Angeles and Burlington, N.C., was the occasion for a $165 million contract from Army Ordnance. Tooling up at the Charlotte Ordnance Missile Plant, Charlotte, N.C., drew another contract for $16 million, followed by a production contract for $20.4 million. Total of the three: over $200 million for the Nike.

The Navy revealed for the first time who was building its Sidewinder (XAAM-N-7), as the Bureau of Ordnance awarded the Philco Corp. a $150,000 contract. Nature of the work was not specified.

Stock splits were prominent on the financial scene at Sperry, Bell, and Thompson Products. Stockholders of Sperry approved an amendment to the corporation's certificate of incorporation; stock will be split two-for-one. Thompson Products stockholders approved a similar move, which increases the firm's common stock from 2.5 million to 5 million authorized shares. At Bell the board of directors passed a resolution recommending a similar split, which would lift the common stock total from 1.75 million to 3.5 million if the stockholders approve the idea at a special meeting on November 1.

Contracts for aircraft production were led recently by a $10 million USAF award to the Boeing Airplane Co. (Wichita) for implementation of B-52 production. Ryan Aeronautical Co. took in more than $7 million in new orders during September, involving subcontracts for aircraft parts and engine components. Cessna Aircraft Co., of Wichita, received almost $4 million from the USAF for 11 T-37A jet trainers.

Profits and dividends were the cheerful center of attention in some parts of the industry. Beech Aircraft Co., which has delivered 99 of its new Twin Bonanzas since the first of the year, expects a profit of more than $5 per share for the fiscal year ended Sept. 30, and Mrs. O. A. Beech, president, sees "a splendid year ahead." Sales were over $78 million and backlog is about $80 million. Directors have voted a 25¢ quarterly dividend.

Jack & Heintz has raised its dividend payment due Nov. 1 to 20¢ a share, up from the 15¢ a share that it has paid since 1951. National Airlines has also declared a dividend, a regular quarterly payment of 15¢ per share, payable Oct. 24. NAL Stockholders have another cause for satisfaction: the National annual report for 1953 has been judged best among those of the domestic airlines by *Financial World;* United and Flying Tigers were runners-up.

SABENA Belgian Airlines stockholders may be less pleased with the contents of their 1953 annual report. SABENA reports a net loss of $472,400 for the year; in 1952 the carrier made a profit of $668,000. Passenger total was up 35.4%, but so many were traveling coach that total receipts rose only 17.3%. The lag in revenues, combined with an expenditure increase of 23.2% over the previous year, put SABENA in the red.

Plants are expanding at Hiller Helicopters and at the Garrett Corp. Hiller has spent $325,000 expanding its floor space by 149,200 square feet and buying new production equipment. Garrett plans to expand its Phoenix, Ariz., facility by 14,000 square feet. The space will be used for assembly, painting, plating, and a process laboratory.

Equipment

• **Douglas Aircraft Co.** confirms the sale of three DC-7B's to South African Airways for $8.4 million, with delivery to begin in 1956. This is the first overseas DC-7 purchase.

• **Alitalia,** Italian airline, has purchased a fourth DC-6B from Douglas.

• **Pan American World Airways** has purchased two DC-6's from Philippine Air Lines on behalf of Compania Mexicana de Aviacion, a PAA affiliate.

Military

• **Defense Department** will obligate roughly $1.75 billion for research and development during this fiscal year, 75% of the national total, according to the National Science Foundation. The total of close to $2 billion is down about 10% from last year's $2.23 billion. Most of the drop is in plant construction.

• **Defense Department** is now permitted to publish proposed procurements in the Commerce Department's "Synopsis of Proposed Procurement and Contract Awards" before issuing invitations for bids.

1000TH BOEING B-47 was rolled from Boeing Airplane Co.'s Wichita (Kans.) Div. plant on October 14th. The six-engine Stratojet, powered by General Electric J47 engines, is also built by Douglas Aircraft Co. at Tulsa, Okla. and by Lockheed Aircraft Corp. at Marietta, Ga. Photo, shows previously unreleased production line scene at Wichita.

SEVEN NORTH AMERICAN F-100 Super Sabres are shown lined up at NAA's Columbus, O. plant. USAF recently placed a $100 million order for the Pratt & Whitney J57-powered fighters which can fly at level flight speeds above Mach 1.

BOAC Plans Order for 10 DC-7D's

An agreement has been reached, subject only to British government approval, for BOAC to place an initial order for 10 Douglas DC-7D aircraft powered by Rolls-Royce RB109 turboprops, AMERICAN AVIATION has learned on good authority. Lord Hives, chairman and joint managing director of Rolls-Royce, and a team of top executives from the British engine company visited the U. S. this month and had discussions with numerous companies including Douglas Aircraft Co. and Westinghouse Electric Corp. The latter has license rights for Rolls-Royce engines in the U. S.

Using the DC-7C's wing and a fuselage 80 inches longer than standard DC-7's, the DC-7D will be a high-performance aircraft cruising at at least 380 mph and having a range of well over 4000 miles with a 15,000-pound payload. Deliveries would start in 1958 or 1959. It is likely that the DC-7D will cost little more than the $2 million-plus DC-7C. The export price of RB109 is stated to be about $80,000.

The DC-7D has been discussed by Douglas with numerous airlines, domestic and foreign. As the largest domestic and foreign operators of Douglas four-engine commercial transports, American Airlines and Scandinavian Airlines System, respectively, are likely to be among those most interested in the project.

Mating of a Douglas airframe with a Rolls-Royce engine is not new—the Canadair Argonaut/North Star, as operated by BOAC, TCA, and the RCAF, represents such a union. Thus, for BOAC in particular there is a precedent. The British airline's active interest in the DC-7D reflects the uncertain position regarding the resumption of service by the de Havilland Comet jets and the improbability of early passenger service by the turboprop Bristol Britannias.

Republic Rehiring; Plans Full Production

Republic Aviation Corp. is planning to rehire between 700 and 1000 of the 7000 employees laid off when production of the F-84F Thunderstreak was ordered reduced. The Farmingdale, L. I., company also decided to:

- Resume the original F-84F production schedule as Defense Secretary Wilson recommended when he visited the plant. The full schedule will be attained by year's end.
- Handle installation of the Wright J65 turbojet engines and other modifications to the undelivered Thunderstreaks on its own. During Wilson's visit, Republic was urged to clear its field of undelivered planes as quickly as possible, letting nearby military or commercial overhaul facilities take care of the required modifications if necessary.

F-84F's have been piling up at Farmingdale because of several factors, including a now-straightened-out shortage of engines several months back.

3 New Planes Included In $1.2 Billion Orders

Air Secretary Talbott, in a first-quarter report, said the USAF has awarded contracts for more than $1.2 billion for aircraft and related procurement since July 1, including initial orders for three new planes, the Lockheed F-104 lightweight fighter, the Convair B-58 supersonic bomber, and the Boeing KC-135 jet tanker.

The F-104 will be built at Burbank, the delta-wing B-58 at Fort Worth, and the KC-135 (formerly the Boeing 717) at Renton, Wash.

USAF, Talbott added, has also stepped up its Boeing B-52 orders, including follow-on contracts to Boeing-Seattle and Boeing-Wichita.

Engine contracts negotiated since July 1 include $50 million to Pratt & Whitney and $22 million to Ford-Chicago for J57's, $34 million to Allison for J71's and $35 million more for T56's, $21 million to General Electric for J73's, and an undisclosed sum for Pratt & Whitney YJ75's. The J75 will deliver about 15,000 pounds thrust.

Aircraft orders include more than $100 million in North American F-100's at NAA-Columbus, an undisclosed sum for the Sikorsky H-37 helicopter (S-56), and follow-on contracts for the Lockheed C-130 turboprop at Marietta, the C-131 at Convair-San Diego, and the Beech T-34 at Wichita.

Airport Advisory Group Named by Murray

A seven-man group to advise on federal aid to airports has been appointed by Under Secretary of Commerce Murray to assist in the evaluation of the fiscal 1955 program and to make recommendations for the preparation and administration of the fiscal 1956 program.

The group includes: Claude B. Friday, president of the National Association of State Aviation Officials and director of the aviation department of New York State; Fred Glass, president of the Airport Operators Council and aviation director of The Port of New York Authority; Don Martin, director of the Metropolitan Oakland International Airport; William P. Fuller, president of the American Association of Airport Executives and director of Fort Worth airport; Louis R. Inwood, director of Philadelphia's aviation department; Walter Bettsworth, manager of Waterloo, Ia., Municipal Airport; and Melvin Nuss, manager of Reading, Pa. Municipal Airport.

New Mail Rate Proposal Hits "Temporary Snag"

CAB's proposed new service mail rate structure for the domestic trunk lines ran into what Board officials considered a "temporary snag" this month as various carriers and the Post Office filed notices of objections.

The CAB proposal, which was a multi-element structure averaging about 41.46¢ per ton-mile industry-wise, would have become effective if no objections had been filed by October 11. However, United, TWA, and intervenor Slick Airways, along with the PO, opposed the Board's proposal.

Eastern, Northwest, and Continental said they were willing to go along, but if others objected they wanted to take part in any hearings. Remainder

of the industry apparently was willing

Defense Budget Pics

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of the industry apparently was willing to accept the Board's proposal.

A CAB source told AMERICAN AVIATION the Board intended to move fast, however, to end the period (started April 1, 1954) during which the industry has been on a so-called "open-rate" status. The Board, he said, would either expedite hearings on its proposal or reach a settlement with the carriers and PO, but would not permit the matter to drag.

Defense Budget Rise To Be "Considerable"

The fiscal 1956 Defense Department budget, which will be submitted to Congress early in January, will call for a "considerable" increase over the $29.6 billion voted this year.

Defense Secretary Wilson said that appropriations "should be and probably will be" higher for the next few years.

News Briefs

Military

A small number of de Havilland-Canada Otters will be obtained by the U. S. Army for evaluation. The single-engine transport was matched against helicopters this summer during tests of advanced or beachhead freighter and ambulance operations.

Col. Bernt Balchen, USAF polar expert, may accompany this winter's Navy expedition to the Antarctic. Then again, he may not. Balchen's assignment is in doubt because of the opposition of some AF officials to Air Force participation in the Navy operation. Those opposed object that the USAF's interests are in the Arctic, not the Antarctic.

Manufacturing

Fourteen Super Constellations were delivered by Lockheed during September, an all-time record. Their value, including spare parts, totalled over $26 million. Seven went to the military (including the Navy's R7V-2 turboprop); the remainder went to KLM (2), Avianca (2), and Seaboard & Western (3).

First vertical flights have been completed on the Transcendental Model 1-G convertiplane. Conversion to forward flight is expected in the near future. Two rotors at the wingtips of the experimental craft tilt forward through 90° to give forward speed of 150 mph.

Transport

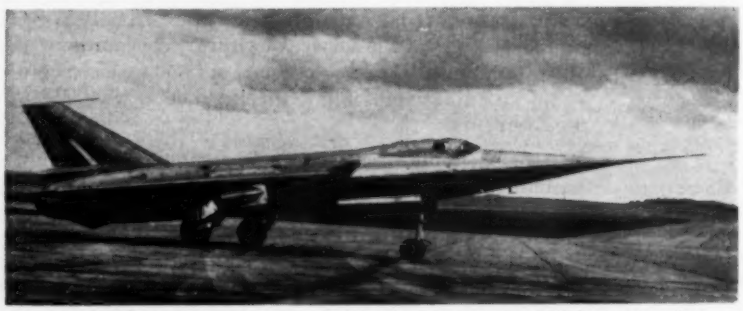
Clarence N. Sayen, president of the Air Line Pilots Association, has hailed the United Air Lines decision to install airborne weather radar in its fleet; Sayen cited earlier pilot requests for such equipment.

The chairman and president of Compania Cubana de Aviacion, Sergio I. Clark, has been replaced by Jose Lopez Villaboy. Villaboy, a Cuban businessman and onetime editor of the Havana newspaper *Mañana,* has recently been active in Cuban airport affairs.

Summer load factors on Frontier Airlines were up 21% over the previous year's totals. For June through September, load factors ran 44%, 48%, 54%, and 45%, topping the previous monthly record of 43%.

A British air transport team arrived this month to study all-weather operations during a two-week visit. The group is headed by S. F. Follett, of the Supply Ministry, and includes representatives of BEA, BOAC, and the ministry of transport and civil aviation. Airlines, CAA, and ANDB will be consulted.

The CAA has approved the Spartan School of Aeronautics, Tulsa, Okla., for flight engineer training. It is the first time in a year that such CAA-approved training has been available.



FAIREY DELTA 2, designed for transonic and supersonic level flight testing, features a "sword-edged" wing and a landing gear which fully retracts into the thin wing. It is powered by a Rolls-Royce Avon engine. Nose section can be lowered in flight to improve visibility. Mid-wing is of delta design.

People

The Ramo-Wooldridge Corp. Guided Missile Research Div., already committed to a $9 million missile program for the coming year, has hired **Dr. Louis G. Dunn** as associate director from California Institute of Technology Jet Propulsion Laboratory where he was director. **Dr. Milton U. Clauser,** formerly head of the School of Aeronautics at Purdue University, was named director of the division's aeronautics and structures staff, and **Dr. James C. Fletcher,** formerly with Hughes Aircraft Co. as head of theory and analysis for the Falcon (air-to-air guided missile), heads the guidance and control staff.

Other changes reflecting industry's growing interest in missiles:

Capt. Charles Antoniak (USN ret.), to Solar Aircraft Co. as engineering consultant on powerplants. Before retirement he was director of tests, U.S. Naval Air Missile Test Center, Point Mugu, Calif.

Dr. K. C. Black to Raytheon Manufacturing Co. as head of communications engineering; **Nathaniel B. Nichols,** mgr. of the research div., moved up to ass't v.p.

Capt. Steadman Teller (USN ret.), former chief of the Navy's guided missiles section in the Office of Chief of Naval Operations, to senior military adviser in Development Planning at Lockheed Aircraft Corp. **Samuel T. Cohen,** nuclear weapons specialist, and **Wilbur D. Snow,** specialist in research and development programing, have also joined Lockheed.

Robert G. Francis to mgr. of production engineering and material, and **Kenneth Hisey** to general foreman at Marquardt Aircraft Co.

Robert G. Hoch to mgr. of the New York region for the Aeronautical Div. of Minneapolis-Honeywell Regulator Co. from the aeronautical office in Fort Worth.

M. Barry Carlton, formerly executive director and coordinator of reliability in the office of the Secretary of Defense, to The Magnavox Co. as gen. mgr. of Defense Products Div.

Robert J. Stein to mgr. of Allen B. Du Mont Laboratories, Government Contract Div., Dayton office, from Acme Aluminum Alloys, Inc.

George W. Craig, formerly with Convair of Fort Worth, joined Camair at Galveston as chief engineer.

CAB CALENDAR

Oct. 25—Hearing, Airfreight Renewal Case (irregular service). Washington, D. C. Docket 4770 et al.

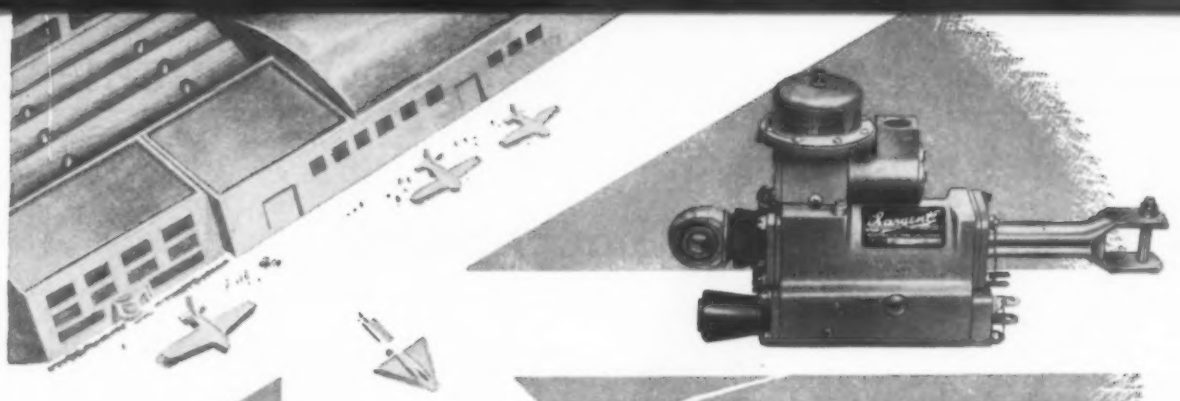
Oct. 26—Oral argument, Ellis & Alaska Coastal Renewal. Washington, D. C. Dockets 6264 & 6307.

Oct 28—Oral argument, North Central-International Falls Service Case. Washington, D. C. Docket 6563.

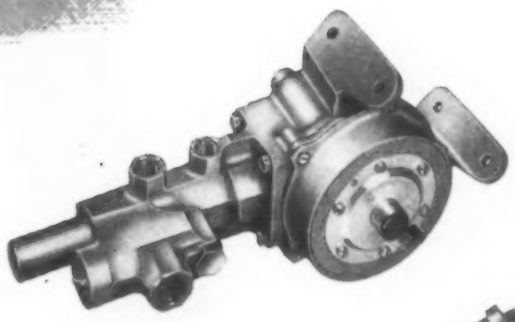
Nov. 2—Prehearing conference, Eastern-Colonial Case. Washington, D. C. Docket 6582.

Nov. 8—Hearing, Commercial Charter Resolutions Case (IMATA & ACTA). Washington, D. C. Docket 6580.

Nov. 8—Hearing, New York-Mexico City Nonstop Case. Washington, D. C. Docket 2909 et al.



Aircraft hydraulic and mechanical controls by Sargent



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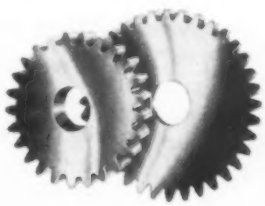

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Personal View

By WAYNE W. PARRISH

Security and Missiles

READERS of this special issue of AMERICAN AVIATION will not have to proceed through many pages to discover how vastly important the guided missile program has become in the nation's defense effort.

But in preparing this review over a considerable period of time, this magazine's staff of experienced editors uncovered two serious trouble spots involving the entire missile program.

Both trouble spots arise from the Pentagon's attitude and regulations pertaining to security.

1. One of these, the more important of the two, vitally affects the very manufacturing industry which has been made responsible for designing and producing missiles. *The truth is that unnecessary security restrictions are actually throttling technical development and progress.*

No one questions the need for sensible and workable security control in the missile field. But when that security control holds back development, when it prevents the available know-how of industry from being adequately and advantageously used, then it's high time to take a look-see and remove the irksome handicaps. Here are examples:

• Only a single engineer cleared for "Secret" or "Top Secret" is now being permitted to work out a problem which normally should require the contributions of three or four top engineers.

• Whereas the research and development projects for piloted aircraft designs utilize the technical brains and skills of teams, missile engineers have to work individually in vacuums with very limited information and without even the knowledge of how a component operates in a missile system with relation to other units.

• Component design is being re-centered in the labs of prime contractors with only a specification drawing of a missile part given to the accessory producer to develop. Basic information about the overall system—a necessity to good design—is being withheld.

• It all adds up to the fact that a vast amount of engineering talent which should be used in initial design is not permitted to enter into the project. There are specific examples where the first design handed to an accessory producer couldn't even be recognized in the finished product, only because of the lack of basic information to start with.

Even the timing is sorely affected by security. Orders for development missile components are let by prime contractors on a project-unknown, timing-unknown basis with orders calling for one, two, or three items, delivery immediately. No information can be relayed as to production possibilities, production timing, potential quantities—all information that is basic to sound business in the piloted aircraft field and other design fields. With component manufacturers in the dark, it is no wonder that progress has been retarded.

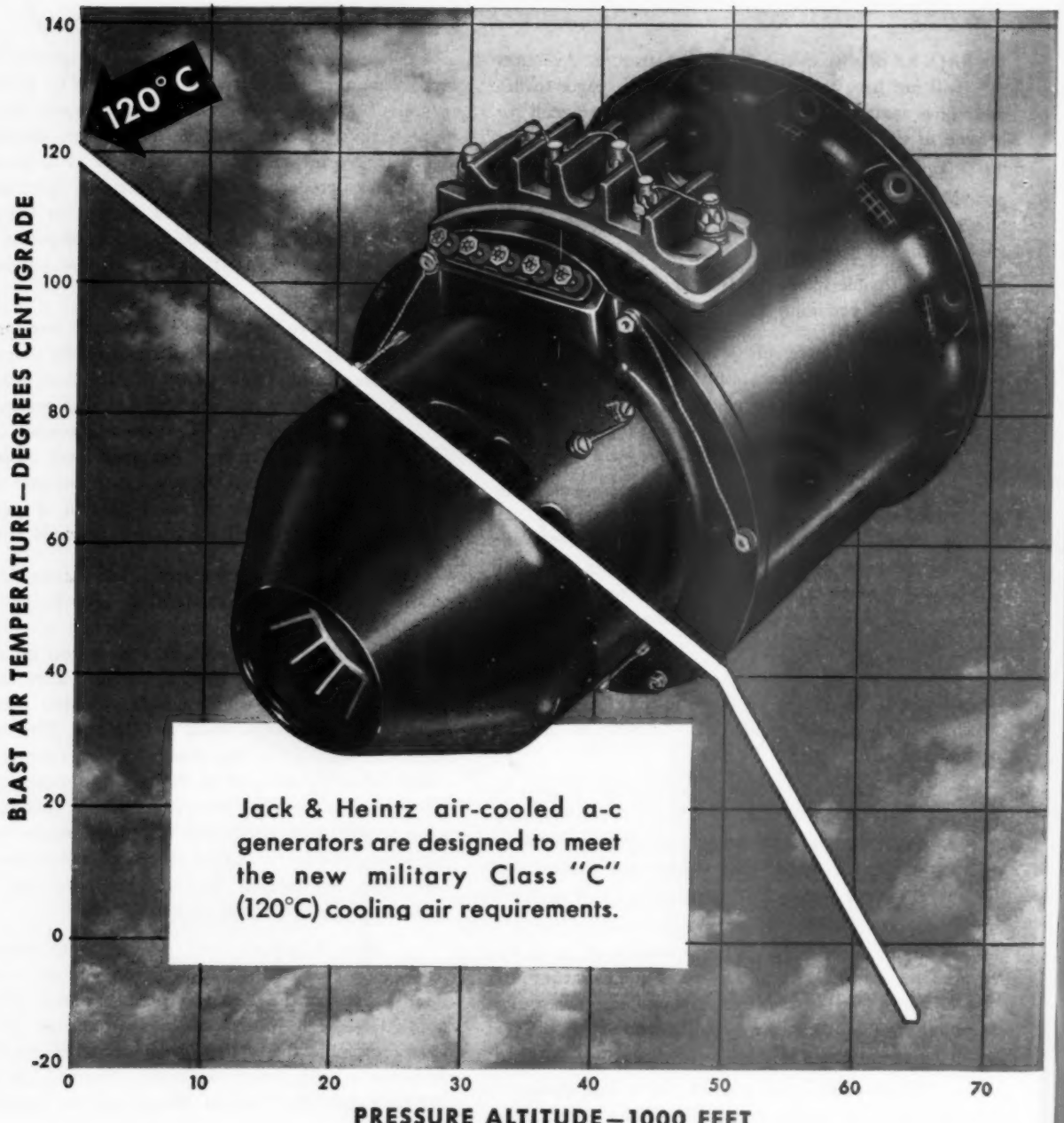
Ironically enough, missile component development is making its way into small miscellaneous model shops growing up around the missile development centers, instead of going to companies with substantial technical resources employing trained engineers. The spread-the-work idea is commendable of and by itself, but these small shops, most of them capable of turning out any sort of one-shot machine work on short order, are not in a position to cope with mass production demands when these demands arise.

2. A second trouble spot is the manner in which security is serving as a blockade to the interchange of technical information and the erratic manner in which the Pentagon "inadvertantly" releases a great deal of information and then "recalls" and "reclassifies" after the basic information has been widely distributed. Most noteworthy example was the Department of Defense Directive No. 4200.5 of March 4 of this year which, in a single stroke, released more information on this country's missile program than had been previously released or leaked. This document, since recalled, contained first official references to many important missiles including the air-to-underwater Petrel and Dove, the Gorgon V, the Sidewinder, and various versions of the Talos and Sparrow.

Some Pentagon offices have gone to extremes in bottling up even the most general sort of missile information. Yet when the Pentagon needs a quick reply to a political hassle it rushes classified information into print, as for example the swift announcement of the Chrysler Redstone missile, heretofore highly classified, to rebut a Senator's claim that General Motors had too much defense business.

A sensible security review is needed, not only for development progress, but also to avoid the release bobbles of the past. • • •

A-C GENERATORS...



Jack & Heintz air-cooled a-c generators are designed to meet the new military Class "C" (120°C) cooling air requirements.

JACK & HEINTZ *Rotomotive*

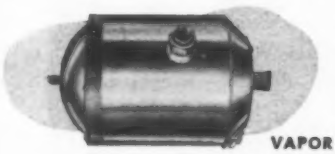
a report from JACK & HEINTZ

New thermal designs give J&H generators wide range of applications

Jack & Heintz air-cooled a-c generators will operate in 120°C environmental conditions. Improved thermal design, including the use of high-temperature insulating materials and increased handling capacity of cooling air, makes this possible. For more severe environmental conditions, Jack & Heintz has developed oil-cooled, vapor-cooled and thermal-lag machines.

Environment-Free Generators

OIL COOLED



VAPOR COOLED

JACK & HEINTZ A-C GENERATORS FOR HIGH-PERFORMANCE AIRCRAFT

	AIR COOLED				OIL COOLED		VAPOR COOLED		THERMAL LAG
Nominal Rating	20 kva	30 kva	40 kva	120 kva†	20 kva	40 kva	12 kva	30 kva	8 kva
Specification(Ref)	MIL-G-6099	MIL-G-6099	MIL-G-6099	MIL-G-6099	MIL-G-6099	MIL-G-6099	J&H	J&H	J&H
Drawing	J&H G284	J&H G282	J&H G281	J&H G180	J&H G192	J&H G190	J&H G75	J&H G188	J&H G186
Volts	120/208	120/208	120/208	120/208	120/208	120/208	120	120	120/208
Speed	6000	6000	6000	6000	8000	6000	12,000	12,000	12,000
Phase	3	3	3	3	3	3	3	3	3
Frequency	400	400	400	400	400	400	400	400	400
Power Factor	0.75	0.75	0.75	0.75	0.75	0.75	0.8	0.8	0.9
Weight	67	75	86	250	95*	165*	46	66	42
Moment	270	370	400	2100	1100*	2250*	270	475	230
Length	14.18	15.86	16	22	23.5	27.25	10.69	13	13
Diameter	11	11	11	11	11	13	9	9	8
Mounting and Type	AND10266 XVI-A	AND10266 XVI-A	AND10266 XVI-A	AND10267 XVII-C	AND10266 XVI Spl	AND20006 XVI Spl	AND20002 XII-E	AND20002 XII-E	AND10262 XII-A

*Includes weight of constant speed drive.
†Blast air temperature limits of MIL-G-6099 apply.

Military specification numbers as used herein are for purposes of product identification only and do not necessarily imply specification conformity.

Jack & Heintz engineering personnel and manufacturing facilities are geared to undertake design and production of complete a-c systems or individual components. We invite your inquiry. Write Jack & Heintz, Inc., 17633 Broadway, Cleveland 1, Ohio.

AIRCRAFT EQUIPMENT

RESEARCH KEEPS **B.F.Goodrich** FIRST IN RUBBER

B. F. Goodrich device lets a man get in where air cannot

1 ZIPPER FLOOR MAKES PRESSURIZING CABINS EASY. Douglas wanted to pressurize the C-124B's crew compartment. But how to handle the floor? It had to stand a total air pressure of 67,000 lbs. And because there was equipment underneath that required servicing, it couldn't be sealed off with a regular sub-floor. B. F. Goodrich engineers devised this rubber sub-floor to do the job. Cables in the rubber give it enough strength to stand 100,000 lbs. pressure. The B. F. Goodrich Pressure Sealing Zipper gives access to equipment yet provides an airtight seal.

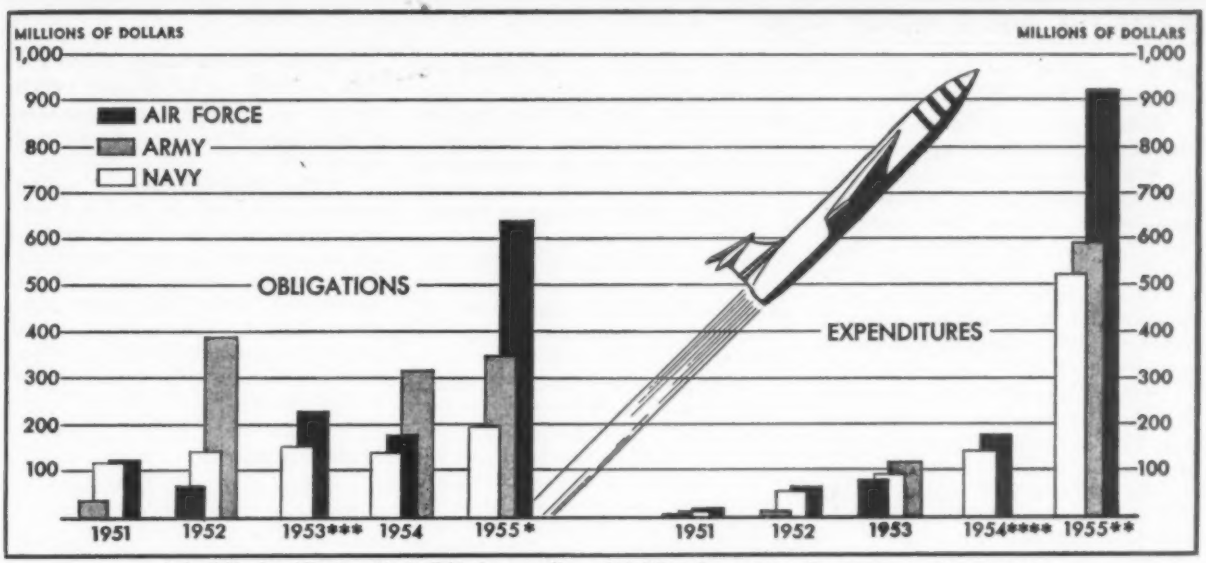
2 SEAL ZIPS OFF TO SAVE TIME. Lockheed engineers needed a seal between the elevator and stabilizer on the Neptune to make control easier. An ordinary fabric seal would work, but dozens of screws would have to be removed every time a control surface was taken off. The B. F. Goodrich Pressure Sealing Zipper proved to be the answer. Its molded lips prevent air flow through the hinge area. Mechanics unzip it in seconds.

3 IT LETS MEN IN—KEEPS FUMES OUT. A standard metal partition between cockpit and fuselage would keep engine fumes out of a jet's cockpit. But it wouldn't let mechanics in unless they removed a lot of screws and bolts. B. F. Goodrich devised a better partition—a fume curtain closed with a Pressure Sealing Zipper. The zipper's rubber lips make an airtight seal, unzip in nothing flat.

4 SHUTS UP TORRENT OF HOT AIR. Designers wanted to make the C-124's hot air duct in six-foot sections. They needed a strong, flexible coupling that would permit easy removal of the sections. B. F. Goodrich Pressure Sealing Zippers solved the problem. They resist heat damage, provide an effective seal, open with a zip.

Pressure Sealing Zippers fit irregular shapes. Can be sewn or cemented. They save space, weight, time . . . Write: *The B. F. Goodrich Company, Aeronautical Sales, Akron, Ohio.*

B.F.Goodrich
FIRST IN RUBBER



* Available for obligation. ** Available for expenditure. *** Minus figure. **** Transferred to other accounts.

Here's how the USAF, Navy and Army have been staking their claims in the missiles field. The trend: Procurement money up from $75 million between fiscal '46 and '50 to $634 million in FY '54.

WHERE THE MISSILE MONEY GOES

There's been a six-fold increase in the Defense Department's spending on missiles since 1946, and R&D money sets the pace. Good advice: Watch Missiles Grow.

MISSILES mean money, not only to the American taxpayer who must pay for their development and purchase but also for the aircraft and electronics industries who can foresee an inevitable drop in plane buying.

It is not that the nation's guided missile program accounts for the bulk of the defense dollars as yet; by the best estimates that situation will not arrive for several years.

But it was only now during the current year that the industry and the American people could get a fairly comprehensive idea of where the guided missile program has been, where it is today, and what can be expected in the near future.

No two sources seem able to agree on the amount of money that has been invested in missiles since their potentialities became apparent in the closing days of World War II. But there is little doubt that the sums appropriated by Congress in the past 10 years represent only a small fraction of what the Defense Department will be seeking in the next few years.

In answer to a Congressional query earlier this year, the Pentagon reported that, counting the money granted for fiscal 1955, about $4.7 billion has been made available during the last five years, i.e., an average of nearly $1 billion a year. This sum was broken down as $2.9 billion for the purchase and production of complete guided missiles and the necessary launching, guidance, and control devices, $1.6 billion for missile research and development, and more than $200 million to expand facilities for testing missiles.

These figures do not include the more than $400 million appropriated for salaries and expenses for the independent National Advisory Committee for Aeronautics, which does research on both missiles and aircraft for all government agencies. Most of NACA's research work and expenditures for wind tunnels and test facilities are applicable to both piloted and pilotless aircraft, so again there is no accurate way of breaking down the investment in missiles per se. But there is little doubt that at least 25% of NACA's budget for the decade can be attributed to missile work.

Jurisdictions settled

A highly significant event taking place this year which will have an important bearing on the role of the services in the missile program is that the Joint Chiefs of Staff are nearing a decision on the missile responsibilities of the three services.

It is expected that when the roles are settled once and for all the relative allocations to the three services in the missile program may change. Thus, whereas the $2.9 billion appropriated for missiles in the past was almost equally divided among the services (much like the total defense budget) on a one/one/one basis, it now seems that if the USAF is assigned control over the large, long range missile, it may receive the edge in future appropriations.

(Under original plans the Defense Department expected to spend $660 million for missiles in fiscal 1955, broken down as $250 million for the Army, $233 million for the USAF, and $177 million for the Navy. This $660 million has since been scaled down to about $500 million.)

More indicative of the importance of the three services, perhaps, is the amount of money each had available for missile order placement as fiscal 1955 began. The Defense Department overall had $1.2 billion in money available for obligation, including $639 million controlled by the USAF, $347 million by the Army, and $197 million by the Navy.

Similarly, of the more than $2 billion available for expenditure on July 1 by the Defense Department, the AF

had $919 million, the Army $593 million, and the Navy $522 million.

Certain trends in the missile field are becoming increasingly apparent.

• Whereas about $50 million was spent on missile research and development by the Defense Department in 1946, the figure had climbed to more than $300 million annually by last year, a sixfold increase. At the same time, the overall Defense R&D program had risen from $500 million to $1.3 billion annually, or about two-and-a-half times.

• Only about $75 million was spent on missile procurement between fiscal years 1946 and 1950, most of it directly in support of R&D. By contrast, obligations in 1951 were $275 million, in 1952 $601 million, in 1953 $383 million, in 1954 $634 million.

• Between fiscal 1946 and 1949, the services were spending much more on research and development of aircraft than on missiles. In the next few years, missile R&D was expanded so that by 1952 aircraft and missile development programs became about equal. Then missile research surged ahead. Best example can be seen in the USAF's requests for new money for R&D in both fields:

	1953 actual	1954 esti.	1955 esti.
Aircraft	$46,721,988	$64,689,975	$33,728,000
Missiles	$129,724,984	$84,742,676	$91,719,000

• Since the end of World War II, several missile test ranges and missile test facilities have been built at a cost of more than $200 million. Included are the AF Missile Test Center at Banana River, Fla.; the Naval Ordnance Test Center at Inyokern, Calif.; the Army's White Sands (N.M.) Proving Grounds; the AF's Holloman Air Development Center; the Army's Redstone (Ala.) Arsenal; and the USAF's $22 million ramjet addition to the Arnold Engineering Development Center in Tullahoma, Tenn.

• In the next two years, more than $100 million will be used to construct operational guided missile stations (to launch Nike missiles) in the U.S. as part of the air defense system.

• Not included in the above figures, but representing an additional tidy sum, are military-owned facilities built for the production of guided missiles. These plants (e.g., Hughes-Tucson, Convair-Pomona, Sperry-Farragut at Bristol, Tenn., Chrysler at Warren Township, Detroit, etc.) were financed out of construction money.

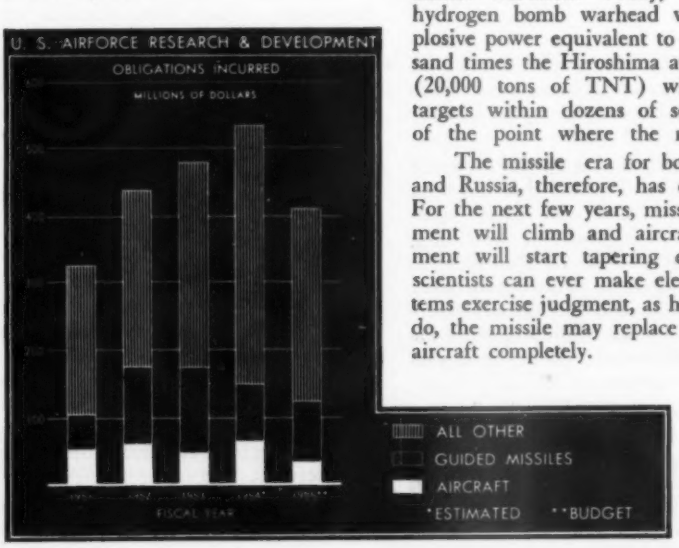
All in all, there is little doubt that the nation's guided missile program is now a multi-billion dollar business which has attracted just about every aircraft and engine company and, in addition, numerous electronic firms (Sperry, Bendix, RCA, Raytheon, Philco, etc.) as well. The most succinct statement on the future of missiles was made recently by Wilfred J. McNeil, Assistant Defense Secretary (Comptroller), when he reported on projected obligations. Aircraft orders, he said, would remain at about the present level but there will be increases in two categories—ship construction and guided missiles.

The reasons for McNeil's statement are logical enough. While it is true that many missiles now in production are designed as supplements (and possibly even replacements) for some aircraft models, and cost much less than the planes involved, the future emphasis on the intercontinental missile will cause a sharp upturn.

Thus while the Hughes Falcon (estimated price: $9000-$80,000 depending on the quantity ordered) and the Martin B-61 Matador (estimated price: $83,000-$250,000 depending on the production run) are relatively low priced, some of the larger long range missiles may well end up costing several millions of dollars apiece. Under such circumstances, something in the Defense Department's budget procedures will have to "give."

That something may prove to be one of three possible alternatives:

• A tremendous increase in the USAF's slice of the budget pie, with the Army and Navy taking proportionally greater cuts than they have in this past. This undoubtedly will be looked on with disfavor by the two senior services, which are already grumbling about the emphasis air power has received in the last few years.



• If the present budget divisions remain in effect, the USAF may eventually have to de-emphasize procurement of other items it purchases, even including aircraft.

• The possibility that a nuclear-powered guided missile (and that presently appears to be the ultimate weapon) will have to result in something similar to the wartime atomic bomb Manhattan District, which was under Army sponsorship. A similar project, to determine the feasibility of such a nuclear missile, would probably be under USAF jurisdiction because of the AF's concern with intercontinental weapons.

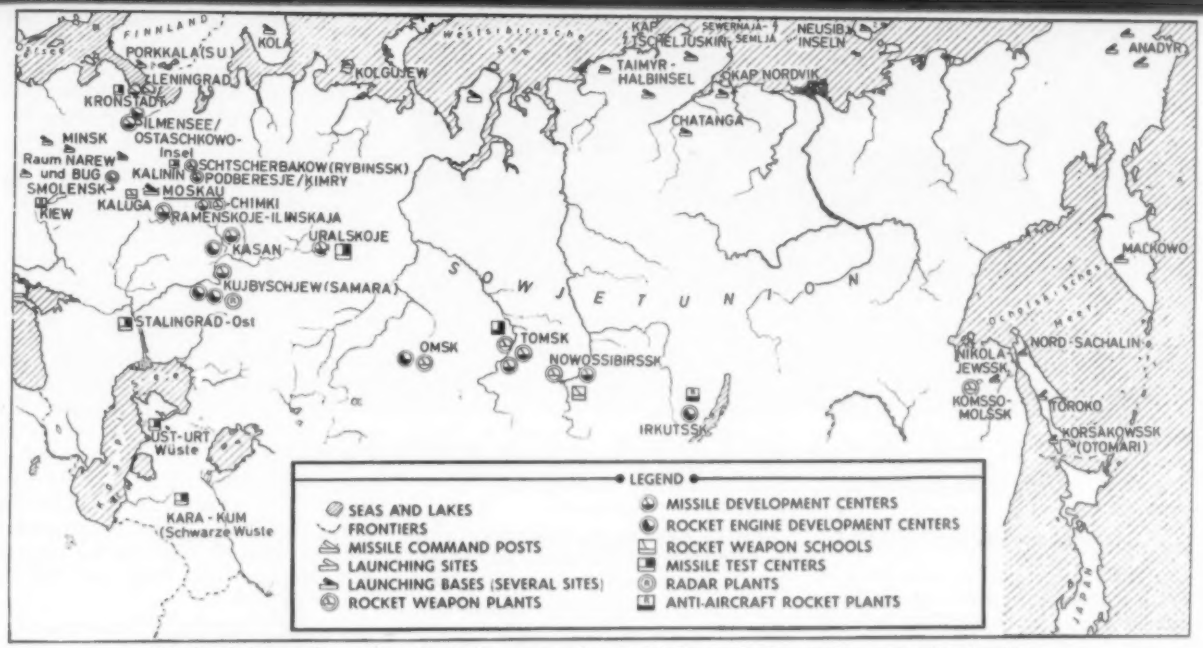
Nuclear problems

Feeling is that the development of a long range nuclear missile, while definitely possible, will involve the use of as much, and possibly even more, scientific talent and money as the Manhattan project. One of the problems which will require the employment of the country's top scientific brains is the determination of exactly how much thrust to give such a missile to make certain that it will reach its earthly target rather than end up on the moon. Informed sources indicate that the provision of too many pounds of thrust might send the missile completely away from the earth. And, they add, it might take as long as 30 years before the missile-satellite returns.

One change in the missile situation resulting from the advent of the hydrogen age has been the tendency to relegate the problem of accurate guidance to one of secondary importance.

Only a few years ago, it was felt that unless the intercontinental missile could hit its transoceanic target with pinpoint accuracy, the vehicle would be almost worthless. Today, however, a hydrogen bomb warhead with an explosive power equivalent to many thousand times the Hiroshima atomic bomb (20,000 tons of TNT) will level all targets within dozens of square miles of the point where the missile hits.

The missile era for both the U.S. and Russia, therefore, has only begun. For the next few years, missile procurement will climb and aircraft procurement will start tapering off. And if scientists can ever make electronics systems exercise judgment, as human pilots do, the missile may replace the piloted aircraft completely. • • •



This detailed map shows where Russia is concentrating its missile production, testing, and related activity.

WHAT DOES RUSSIA HAVE?

Though lacking long-range strategic missiles there's a rebirth of interest in Moscow

IF THE WESTERN world and America want to continue living in freedom, the Soviets must be beaten in the development of intercontinental missiles with atomic warheads. The free world must remain ahead constantly in the construction of new long-range weapons and must seek to increase this advantage continuously. This unequivocal warning was voiced recently in Congress by Senator (and former Secretary of the Air Force) Stuart Symington.

Under these circumstances, an appraisal of the status of Soviet missiles is extremely significant.

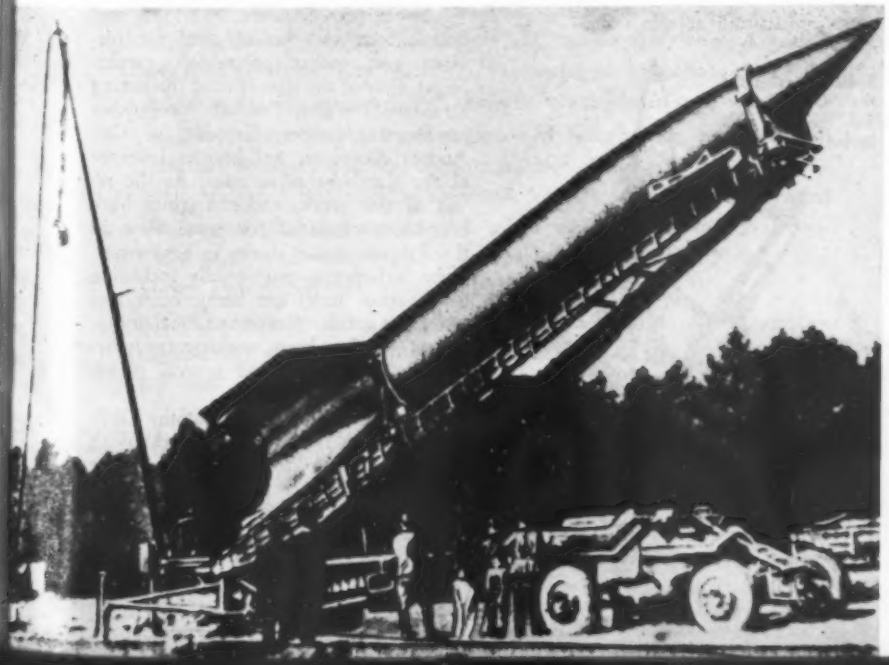
At this time the Soviet missile is still a tactical weapon of the army, but, since technical developments assure that it will become intercontinental in the next few years, establishment of an independent missile force is only a question of time. Here is how it has been developing:

As early as 1946 Air Marshal Konstantin Vershinin (then commander-in-chief of the Soviet air force) asked Stalin to establish an independent rocket force. But he was not able to prevail over the conservative attitude of the army and air force and so was replaced by General Pavel F. Shigarijev, a man who had expressed objections to an independent strategic force comprising long-range bombing weapons.

Development of German V-rockets had begun in August 1945 in the Soviet-occupied zone of Germany and little more than a year later had been transferred to the Soviet Union. This led to the mass production of rocket weapons in various plants even though they still were regarded as purely tactical weapons.

In 1949, however, as evaluation of these German weapons began to open up entirely new possibilities for Soviet warfare, the Soviet Union established in Moscow (under the Ministry of War) a special administration for rockets and V-weapons. This special administration is headed by the well-known airplane constructor, A. S. Yakovlev.

Now, with Malenkov (a certified engineer and former air force consultant to Stalin) displaying an open mind regarding new technical developments, Shigarijev and other conservative party



Russia's missile effort has included much time spent with improving the German V-2 (A-4) rocket, shown here on its Meiller transport and firing platform.

Powered by a liquid rocket engine, the Soviet M-1 grosses 3300 pounds, is 15 feet long and 24 inches in diameter. Maximum speed of Mach 1.3.

officers are apt to lose their influence unless they adopt themselves. Marshal Vershinin is regaining influence and Maj. Gen. Repin is expected to be chief of staff of the new independent rocket force.

Strategic Conception

The strategic goal is clear. Since an attack by neither land nor sea can bring decisive success over the U.S., only the air force's long-distance bombing command and the new rocket weapons remain. These alone can carry atom and hydrogen bombs to the American continent. At this time, however, the rocket force is far from possessing missiles with sufficient range for strategic use against the United States. It is still regarded as a prolonged arm of the artillery.

Launching bases are being built in large numbers in the Baltic region. The satellite countries and western Russia can be used for tactical bases against Europe and they comprise a considerable threat. It has recently been learned that launching bases are being built along the polar sea, on the Chukotski Peninsula, Kamchtka, and Sahkalin. Some are equipped for defensive purposes; others are intended for bombarding Japan.

The bases along the polar sea can be effective only in attacking the United States at some future time by means of intercontinental rockets.

Peenemunde

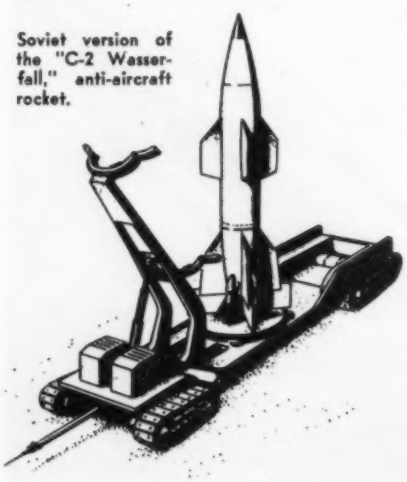
The development of Soviet rocket weapons since the twenties has been limited to solid fuel rockets. Solid fuels cannot be used for large rockets because they provide too small a range. Thus the new Soviet rocket weapons for extended tactical and strategic tasks are based on the material the Soviets found in their occupation of Germany in 1945.

Their occupation included the site at which the V-2 (A-4) was developed, the army establishment at Peenemunde, the subterranean workshops for V-weapons in Thuringia with the well-known "Mittelwerke GmbH" works in Niedersachswerfen, Klein-Bodungen, the rocket testing site at Lehesten, the transferred installations of the Walter-Raketentriebwerk/Walter Rocket Works/ in Prague (formerly at Kiel), the testing site of the Peenemunde army establishment at Heidelager in Poland, and other such objectives.

Although many prominent scientists went to the the west, and American troops occupied the subterranean works in Thuringia first, approximately 200 specialists formerly at Peenemunde left for the Soviet Union in October 1946. In Thuringia the so-called "Rabe" rocket institute came into being under the direction of the scientist Helmut Grottrup (of Peenemunde), who had first been taken prisoner by the Americans. The development and the construction of V-2 (A-4) missiles continued in the subterranean works in Thuringia with as many as 2500 employees at times.

Soviet Professor Artakianov assumed responsibility for the administration and reconstruction of the partly destroyed Army installation at Peenemunde, and soon the largest testing site for V-missiles (the P VII) was back in operation. The "Rabe" rocket institute was ordered to complete all the projects found (some of the material had become lost in transfer to Western Germany). Two special railroad trains from which V-2 missiles could be fired were constructed at this time.

Soviet version of the "C-2 Wasserfall," anti-aircraft rocket.



The new rocket propulsion test set-up which had been built at Lehesten was dismantled completely and taken to the Soviet Union. On October 22, 1946, 11 top scientists, among them Dr. Umpfenbach (formerly of the Physikalisch-Technische Reichsanstalt), Dr. Schwarz, oxygen expert Haase, and 200 specialists, left for Moscow.

It is some consolation that about 100 specialists from Peenemunde, among them Professor Wernher von Braun, Dr. Ernst Steinhoff, Brigadier General Walter Dornberger, and Professor Hermann Oberth, escaped Russian hands.

Most of the 200 specialists who were deported to the Soviet Union were production specialists in rocket propulsion mechanisms. A few were experts in aerodynamics. However, some control and electronics engineers (of the Askania and Lorenz firms) were among them. They are still in the Soviet Union.

Use German experts

A so-called "V-2 clearing center" established at Moscow-Chimki is still operating. A larger group of German specialists was brought to the island of Ostashkovo on Lake Ilmen, south of Novgorod and northwest of Moscow. *(The scientists still live on the island of Ostashkovo, on Lake Ilmen although this group suspended its work on rocket missiles almost two years ago. The German experts are kept from constructing the missiles which they developed and do not know if and where their missiles are being produced.)* At any rate, valuable work was done here from 1947 to 1952.

Specialists on controls and electronics were brought to Ilinskaja/Ilyinskoye/ near the Ramenskoye testing airfield, 26 miles southeast of Moscow. Specialists for rocket propulsion mechanisms and a few Askania experts went to Kuibyshev.

South of Kuibyshev, in Kryash and Batraki, are two testing sites for turbines and rocket propulsion mechanisms. One of the sites is used for testing improved Walter rocket propulsion mechanisms, under direction of Col. Andrey Kostikov, well-known inventor of the Katyusha salvo guns. As the result of this work, rocket engines have been mass-produced for some time in the Frunze motor works in Kuibyshev. Here turboprops, purportedly including a two-spool unit, are being built and tested. Another Kostikov collaborator, Ivan Gvai, has been working for years on the development of several rocket missiles.

It was at Podberesje that the DFS-346 rocket plane was perfected. With it the German test pilot Wolfgang Ziese is purported to have made the first supersonic flights. This plane model

contributed much to the development

General Vasilij Stalin's importance

in the air defense district of Moscow

which only missiles with long ranges

Then too, the construction of such

be ready. Another reason for the Soviets

contributed much to the development of a rocket fighter plane that is now being mass-produced. Rocket plane designs EF-466 F and EF-468 also originated in Podberesje.

Mass production of tactical rocket missiles, mostly patterned after the V-2, has been under way for years at a dozen different plants. The productive capacity of these plants is estimated to be 2000 missiles monthly.

Missiles built at Moscow

Although not yet very efficient, anti-aircraft rockets have existed for a long time. The weapon factory at Sestrovetsk, 21 miles northwest of Leningrad makes them. This factory employs approximately 10,000 men, although some of them are constructing anti-aircraft guns.

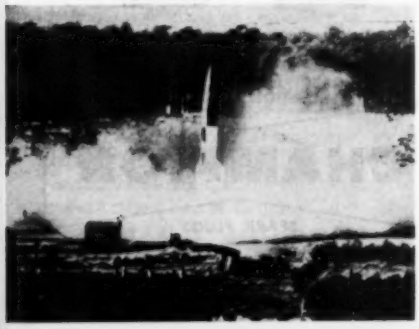
Guided missiles have been built since 1947 in factory 456 in Moscow.

There is another factory in Tomsk worth mentioning. It has the secret number 4-A and, in a testing area near Tomsk, rocket weapons similar to the German Rheinmetall-Borsig R-1 and R-3 Rheintochter rockets are tested. V-2-like missiles are manufactured in a branch factory of the Moscow SIS automobile plant. Anti-aircraft missiles are being manufactured in various plants in Kiev and at Irkutsk, on Lake Baikal. At Badakshan, in the Province of Turkestan, the southernmost territory of the Soviet Union, are several plants which produce missiles.

Until recently the easternmost plant of the rocket industry was located at Lake Baikal, but rockets are now also being manufactured in the Far East. The plant for missile parts at Voroshilovsk, which collaborates with a final assembly plant at Komsomolsk on the Amur River, is an example. The plant was finished in 1953 and began to produce in 1954. It is said that a long-range rocket is being built here.

Several East German plants produce parts, especially radar tubes and measuring and control instruments. These include the Radio-Werke Nr. 1 plant in Erfurt and the RFT-Werke and plants in Leipzig and Zwickau. Furthermore, an institute for research in aerodynamics was established on the island of Rugen, which is a rocket base.

Peenemunde, wartime center of V-2 rocket development, is in Russian hands and used for test purposes. No production is handled there.



General Vasilij Stalin's importance has decreased more and more since the death of his father, but for many years (as a fighter plane inspector) he promoted the organization of a rocket plant force for defense purposes and dedicated all possible personnel to this task. Malenkov, who prefers to follow the counsel of actual experts rather than that of party people, has not taken part in this project.

The inadequate capacity of the tube, controls, and measuring industries in Russia is troublesome. Even today certain types of tubes must be bought on the black market of the western world. Companies producing rocket engines complain about the lack of certain chemicals. The metallugrical industry likewise is unable to deliver all the materials demanded in the desired quality.

The so-called submarine rockets are a real threat. They are missiles of short-to-average range which are to be used against America from submerged submarines. As early as 1942, the Peenemunde army establishment acted upon designs of scientist Dr. Ernst Steinhoff. Near the Greifswald Oie (a small island) powder rockets were fired from a submarine submerged 30 to 40 feet under water. Tests in the summer of 1942 showed that all the powder rockets that had been fastened onto the deck of the submarine could be fired without difficulty.

Submarine tests

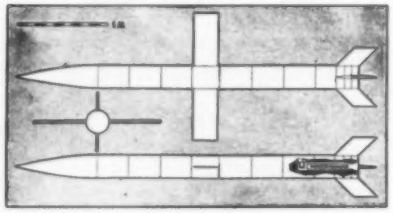
In the fall of 1943, a submarine demonstrated that it could drag three cigar-shaped, submergible buoyant containers about 110 feet long. V-2 rockets were to be fired from these containers under water. The difficulties were manifold and tests were discontinued until the end of 1944. A sketch of the underwater firing device for a modified V-2 (A-4) later fell into the hands of the Soviets. The Soviets have continued these tests on submarines and the American Navy has undertaken similar tests in the Pacific.

It is quite possible for the Soviets to employ rocket missiles against the United States from submarines, and such missiles need not have much range. Reports show that the enormous Soviet submarine fleet is to fulfill another task also. It is planned to provide them with guiding equipment to control long-range rockets on the last lap of their trip through the air.

While Soviet interest in cars for road transportation is small, it is extraordinary with respect to the development of railroad trains (so-called FMS-trains consisting of 40 cars) each with a launching car, measuring car, and a tank car.

Anti-aircraft rocket batteries were set up in September or October 1952, in the air defense district of Moscow (MWO). The existence of such batteries has also been determined in the Baltic region and near Leningrad. The standard equipment of these batteries consists of improved German anti-aircraft rockets of the C-2 Waterfall and Henschel Hs-117 construction type. An anti-aircraft rocket with delta wings has also been observed. Anti-aircraft units of the army in East Germany have been equipped for some time with gun motor carriages on which rocket rails are mounted. The new cruisers of the Sverdlov class are equipped with anti-aircraft rockets.

Some time ago the construction of launching platforms was begun along the polar sea, on the Taimyr Peninsula. Likewise, launching platforms on the Chukotski Peninsula, near Anadyr and on the Kamchatka Peninsula are ready for use. The former launching platforms only make sense if long-range rockets are being developed which have a range sufficient to reach strategic ob-



M-100, an air-to-ground missile used for testing in the Mach 0.9 to 1.3 range, grosses 990 pounds and is powered by 3400-pound-thrust rocket engine.

jectives. A fixed launching platform has been found on Sakhalin Island, which will fire an unknown long-range rocket missile with a take-off weight of about 90 tons.

In view of their position near the main Japanese islands, the other launching platforms in this area, such as those near Toroko and Korsakov (formerly Otomari), are clearly intended for tactical missiles with ranges of seven or eight miles. The same holds true of the bases on the mainland west of Sakhalin and of the Japanese islands. Numerous new launching positions are located near Nikolayevsk, Vladivostok and Ryojun (Port Arthur).

There is a testing site for rocket missiles on Kolguev Island in the Barents Sea. In the Baltic region alone, dozens of launching positions have been constructed ready to cover the Baltic Sea with an arc of fire, if need be.

Do the Soviets have long-range missiles? The answer to this decisive question is a *yes*, with reservations. For years, work has been under way at the research center at Moscow-Chimki on the design and construction of the two-stage long-range M-103 rocket. Launching sites of the Soviet Union, from

which only missiles with long ranges can logically be used, must be regarded as further proof. To employ tactical rocket missiles with small ranges at the edge of the polar sea (for example at the Nordvik Cape) would not make sense.

Then too, the construction of such large and numerous launching sites in regions with permanently frozen ground requires time. Since construction was begun two years ago, the assumption may be justified that in the near future various long-range rocket missiles will be ready. Another reason for the Soviets emphasis on development of such rockets lies in the fact that their long-range bomber force has not yet achieved the striking power of the American strategic bombing command. • • •

RUSSIA'S MISSILE ARSENAL

M-1: Developed for testing at Podberesje. Propulsion consists of a liquid fuel rocket built into the tail utilizing hydrogen peroxide, hydrazine hydrate, and alcohol as fuel. Take-off effected by means of three dropable auxiliary solid fuel rockets out of a circular launcher. Take-off weight, including auxiliary rockets, about 3300 lbs.; without, about 1450 lbs. Length 15′ max.; diameter 24″. Regular tapered wings at mid-section of the hull. Control in form of fins at tail which have 45° sweepback angle. Thrust performance of the Walter rocket propulsion mechanism first installed was 3400 pounds for 30 seconds. Three rockets using solids have thrust performance of 3640-3900 lbs. each. Burning period is 15 seconds. Said to achieve a maximum velocity of approximately Mach 1.3.

M-100: Air-to-ground trial missile for testing massive forms in Mach range of 0.9 to 1.3. Rocket propulsion mechanism for solids with a performance of 3400 lbs. thrust. Weight of the mechanism 286 lbs., powder 154 lbs. Total weight 990 lbs. Take-off takes place from a carrier plane at a high altitude. Various versions with rectangular and delta wings of steel have been tested. Developed at Podberesje.

M-103: Two-section long-range rocket. Development begun at Lehesten in Eastern Germany, later continued at Moscow-Chimki. So-called 120-ton rocket. First section, with take-off weight of about 48-68 tons, was provided with a propulsion mechanism furnishing an initial thrust of 120 tons. It is an improvement of the A-9 rocket from Peenemunde. Second section of the rocket weighs about 20 tons and has a thrust of 35 tons (6 tons more than the A-4 from which it was developed and 10 tons more thrust performance). Computed range of this two-section rocket is 1850 miles.

Missile similar to Matador: Purportedly tested in Arctic in February 1954. Firing range of first test—700 miles. Range is to be extended to 1500 miles. Unconfirmed.

Improved A-4 (V-2): Already-known missile (take-off weight 30,000 lbs.), maximum range 200 miles, has been improved and found with certainty in the armament of the rocket force units.

Long-range missile: Height about 65′, diameter 11′. Almost same as V-2, with a range said to be 3400 miles. Probably identical with the M-103 (or A-10 with a range of 3500 miles).

Winged rocket (improved A-9): First models had a range of 400 miles, later purportedly 530 miles. The A-9 had a planned range of 300 miles.

Submarine rocket: Soviet model with a range of about 140 miles. Said to be launched at the depths as much as 295 ft.

Gvai rocket: Designer is Ivan Gvai, assistant to inventor of Katyusha salvo guns. Work being done on several versions.

Molotov rocket: Guided missile for use from surface ships. Unconfirmed.

Polytechnical Institute Tomsk: Postal rocket mentioned in an official Soviet report. First tests at Tomsk in 1952.

RS-82: Air-to-ground rocket with a caliber of 82mm, length 2 feet, maximum velocity of 780 mph., explosive charge 13.4 ounces.

25-kg rockets: Anti-tank rockets for planes. Maximum velocity 550 mph. Piercing effect of 6.7″ on tanks. Being used since 1943.

Improved R4/M: German plane-board R4/M rocket, improved. Observed on MIG-15 turbo-fighters. Caliber about 55mm, explosive charge 15.8 ounces.

Air-barrage rocket: Developed from rocket using solids in use since 1943. One purpose to shoot wire into air as defense against airplanes. Improved as a multi-purpose missile. Range 35 to 40 miles. Thrust performance 17,000 lbs. For both surface-to-surface and surface-to-air use. Unguided.

Katyusha (Stalin's organ): Salvo gun of World War II. Several types known. Standard has 42 missiles weighing 17.6 lbs. each. Rocket missiles have range of about 3 miles. Other types had missiles weighing 30 lbs. with range of 6 miles.

C-2 Waterfall: Surface-to-air anti-aircraft rocket which can be guided. Small rocket developed from the A-4 (V-2). Rocket using liquid fuel (sulfuric acid and vinylisobutyl ether), thrust 17,000 pounds, altitude reached 30,000-50,000 ft. Take-off weight 7500-7800 pounds including 150 lbs. nitrogen, 3300 lbs. sage, and 990 lbs. of visol. Horizontal range of up to 20 miles, maximum velocity 1200 mph. Total length 19.6′, diameter 27.5″.

Taifun Electro: Unguided anti-aircraft rocket with liquid fuel rocket. Construction similar to British "Z-gun," slender form with four small stabilization surfaces at the end. Total length 6′, dia. 3.9″. Take-off weight 110 lbs. of which 44 lbs. is cell, 22 lbs. is fuel (sage, SV-Stoff—code for an oxidizer containing 98% nitric acid and visol), and 44 lbs. is warhead. Initial thrust 2200 lbs. which drops to 1320 lbs. after 3 seconds. Maximum velocity 2700 mph, maximum altitude 50,000 ft., horizontal range 7.5 miles.

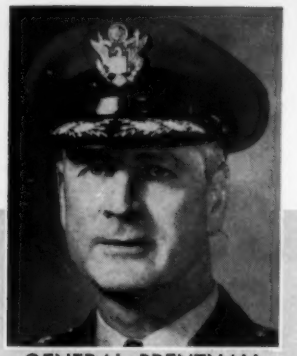
(One of the above two missiles also used on warships of the Soviet Navy).

Rheinmetall-Borsig A.G. "Rheintochter": Two-section anti-aircraft rocket. Length 19.8′, span 6′. Maximum velocity 310 mph. Tests with improved models were made on the testing site near Tomsk.

Tactical rocket missile: Multiple-purpose missile for surface-to-surface and surface-to-air use. Range 35-40 miles, thrust 17,000 lbs. New Soviet model.

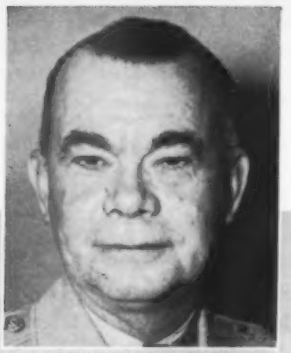
Henschel Hs-117 "Butterfly": Guided anti-aircraft rocket with two solid fuel auxiliary rockets dropped out of a frame after a vertical take-off. Propulsion (a) BMW-109-558, dry weight 185 lbs., with fuel 340 lbs., diameter 14″, length 106″; fuel-sage (SV-Stoff) 128 lbs. and Tonka (code for several types of hypergole rocket propellants) 26.5 lbs.; thrust 840 lbs., burning period with full thrust 35 seconds. (b) Walter HWK-109-729, dry weight 143 lbs. Fuel 320 lbs. including 150 lbs. H_2SO_4 and 25 lbs. gasoline (B-Stoff—code for different types of rocket propellants, usually hydrazinhydrate). Thrust 810 lbs. Two dropable auxiliary rockets of the Schmidding 109-553 type. Span 6.6′, wing area 12 sq. ft., length of hull 12-13′. Take-off weight up to 1000 lbs. Maximum velocity 700 mph. Range 20 miles with a 50 lb. warhead and correspondingly less with a 90 lb. warhead.

Ramjet missile: Guided anti-aircraft rocket with ramjet propulsion and auxiliary rockets for take-off. "Kranich" guiding system by Professor Wagner. Construction similar to the Hs-117.



GENERAL BRENTNALL

ADMIRAL SIDES



GENERAL ROPER

Guided Missiles Interdepartmental Operational Requirements Group

THE MISSILE PLANNERS

AN EXTENSIVE NETWORK of missile planners in the Pentagon is directing a widespread U. S. program which calls for increased speed in research, development, and production of guided missiles.

Who are the key missile men and in what fashion are they providing U. S. missile management? What are they doing to integrate the overall missile effort among the three military services?

A principal aim today is to keep the Air Force, Navy, and Army from duplicating missile projects when no advantage is apparent. In some cases doubling-up can be beneficial, such as when attempting to solve technical problems or to arrive at a practical production item more quickly.

In control of deciding which service develops what missile for what purpose are these Pentagon agencies—the Department of Defense and the Joint Chiefs of Staff.

The top level

The office carrying the most weight in such decisions is that of Donald A. Quarles, Assistant Defense Secretary (Research and Development). Quarles speaks for Defense Secretary Charles E. Wilson in all R&D matters, and most Defense missile work at this stage falls in the R&D category.

Quarles

In Quarles' office top decisions in the military missile management field come from the Coordinating Committee on Guided Missiles. This committee is chairmanned by Dr. D. P. Barnard, an assistant to Quarles. T. C. Muse, also in Quarles' office, is the committee secretary. The remaining members include:

• **Army**—Brig. Gen. K. F. Hertford, Deputy Assistant Chief of Staff (G-4, Logistics) for Research and Development.

• **Navy**—Rear Adm. J. H. Sides, director of the Guided Missiles Division in the office of Deputy Chief of Naval Operations (Air).

• **Air Force**—Maj. Gen. James McCormack, Jr., Director of Research and Development in the office of Deputy Chief of Staff Development. (*McCormack, who recently assumed this AF post, had not yet been officially appointed to the Quarles committee although the appointment will be automatic because of the AF job he now holds, officials said.*)

• **Assistant Defense Secretary (Applications Engineering)**—W. H. Martin from the office of Assistant Defense Secretary Frank D. Newbury.

Of recent importance is the establishment by Secretary Wilson of an ad hoc committee to study development and utilization of guided missiles by the three military services.

Newbury, of Applications Engineering, is chairman of the group. This indicates that the committee may be largely concerned with speeding up the movement of missiles from the development stage into production. Pentagon authorities pointed out, however, that the Newbury committee would survey the entire missile field, including research and development, production, financing, and use of missiles by the services.

Besides Newbury, the committee includes Quarles; Wilfred J. McNeil, Assistant Defense Secretary (Comptroller); and Adm. Arthur W. Radford, chairman of the Joint Chiefs of Staff.

Thus, Quarles, Newbury, and also Thomas P. Pike, Assistant Defense Secretary (Supply and Logistics), play important roles in top Defense Department missile management. These three assistant secretaries have absorbed the work that was formerly done by the now-abolished Office of Guided Missiles, which was headed by K. T. Keller, Chrysler Corp. board chairman.

Keller's group coordinated guided missile planning of the three armed services and advised the Defense Secretary on missile matters since 1950 up to September 1953 when the office was disbanded. Keller is credited with diverting much of the groundwork toward current missile management.

The Joint Chiefs of Staff level

The other highly important standing group fashioning missile policy in the Pentagon works under the Joint Chiefs of Staff. It is known as the Guided Missiles Interdepartmental Operational Requirements Group (GMIORG) and is headed by Maj. Gen. S. R. Brentnall, AF Assistant Chief of Staff for Guided Missiles.

Other members of the group are Adm. Sides, who also serves on the Quarles committee, and Maj. Gen. H. M. Roper, Army Deputy Chief of Staff, G-3 (Research Requirements and Special Weapons).

Newbury

Brentnall, Sides, and Roper confer frequently, coordinating the missile efforts of the three services. What they decide goes directly to Adm. Radford, JCS chairman and top military policy maker.


Barnard


Hertford


McCormack


Martin

THE MISSILE PLANNERS

The trio makes recommendations as to the guided missile program for each service.

There are many areas, of course, in which precise agreement has not been reached. Settling on ranges for surface-to-surface missiles has been a problem.

GMIORG pools all information and comes up with detailed reports covering current problems.

Missile management extends further down the ladder from the Defense Department—JCS level. Each military service has its leading missile men, some already mentioned, but the organizational set-up varies in each.

The Air Force

The Air Force appears to be a step ahead in its missile management organization. Brentnall is "Mr. Missile" and has a direct line to Gen. Nathan F. Twining, AF Chief of Staff.

This close liaison between Brentnall and Twining was only made possible in April when Brentnall's post was elevated to that of Assistant Chief of Staff for Guided Missiles. Previously, he was in charge of missiles under the Deputy Chief of Staff/Operations.

Brentnall says that this organization change gave more emphasis to missiles and has "pulled the parts together" in the complex field by providing a focal point at which the AF missile effort could be coordinated.

The Navy

In the Navy, Sides' work is comparable to that of Brentnall. As Guided Missiles Division director, Sides works through Vice Adm. R. A. Ofstie, Deputy Chief of Naval Operations (Air). Ofstie, rather than Sides, is the direct link to Adm. Robert B. Carney, Chief of Naval Operations for air launched missiles. In other categories Sides reports to Carney.

The Marine Corps maintains a liaison officer in Sides' office. He is Col. Bruce T. Hemphill.

The Army

In the Army, missile management is more diversified than in the other two services, Roper is responsible for *missile operations* under G-3 (Operations) while Hertford is responsible for *missile R&D* under G-4 (Logistics). The Army may revamp its missile management, perhaps along the lines of the AF's organization, but this is not expected in the immediate future.

Research and development

With relatively few missiles out of the many under development at what is considered the production stage, most of the thinking in pilotless aircraft has to be directed toward R&D. However, limited production is necessary in a missile R&D program since up to 100 (or even more) may have to be produced, tested, and fired before determining whether the product should be mass produced. Thus, missiles pose a different problem from aircraft, where a couple of prototypes can usually provide the answers.


Radford

Those associated with research and development in the military services, of course, deal in pilotless aircraft among their varied duties. In the civilian secretariats of the three military services, the following fall into this category: Air Force—Trevor Gardner, Special Assistant for R&D; Navy—James H. Smith, Jr., Assistant Secretary of the Navy for Air (who has Navy R&D responsibilities); Army—Frank H. Higgins, Assistant Secretary for Logistics (R&D).

It should also be noted that various special scientific groups delve continually into the missile field. In the AF, particularly, the Scientific Advisory Board plays an important role.

Below these groups of the missile policy makers in the services, missile management extends into lower echelons—into the actual operating level.

In the AF, the Deputy Chief of Staff/Development (Lt. Gen. Donald L. Putt) and the Deputy Chief of Staff/Materiel (Lt. Gen. Bryant L. Boatner) spend a great deal of their time in the pilotless aircraft area. They oversee the work conducted by Air Research and Development Command and Air Materiel Command.

In the Navy, the Bureau of Aeronautics, which has a Guided Missiles Division, and the Bureau of Ordnance share the missile work. Although BuAer's missile programs tend to bear more directly on missiles in their relation to aircraft, rather than ships, there is no set line of demarcation as to which missiles BuAer should develop in contrast to those under development by BuOrd.

Missile work of the two bureaus is "controlled topside to prevent duplication," but each bureau is free to request permission to develop any type of missile. Thus, BuAer and BuOrd are competitors, in a sense. In addition, much of the aerodynamic and electronic work for BuAer and BuOrd is done by the Office of Naval Research.

U. S. missile management may be extended soon to the international field, if a proposed cooperative effort with Great Britain materializes.

Next step—international

The possibility of an exchange of missiles between the U. S. and Great Britain was mentioned recently by Secretary Wilson. He said the two countries are not quite ready for acceptance of each other's missiles, but the plan is to bring about a "standardization on certain types of missiles" for the mutual benefit of both countries.

Top missile men in the Pentagon have held numerous conferences with Britain's defense leaders in recent months, trying to step up this cooperative effort. Up to now, cooperation has been limited to exchanges of visits, inspections, and release of missile data between the U. S. and Britain.

It was indicated by top Pentagon officials, however, that by spring a definite plan should be worked out. This may include U. S. permission for the British to use U. S. missile test ranges, which have grown considerably in recent years.

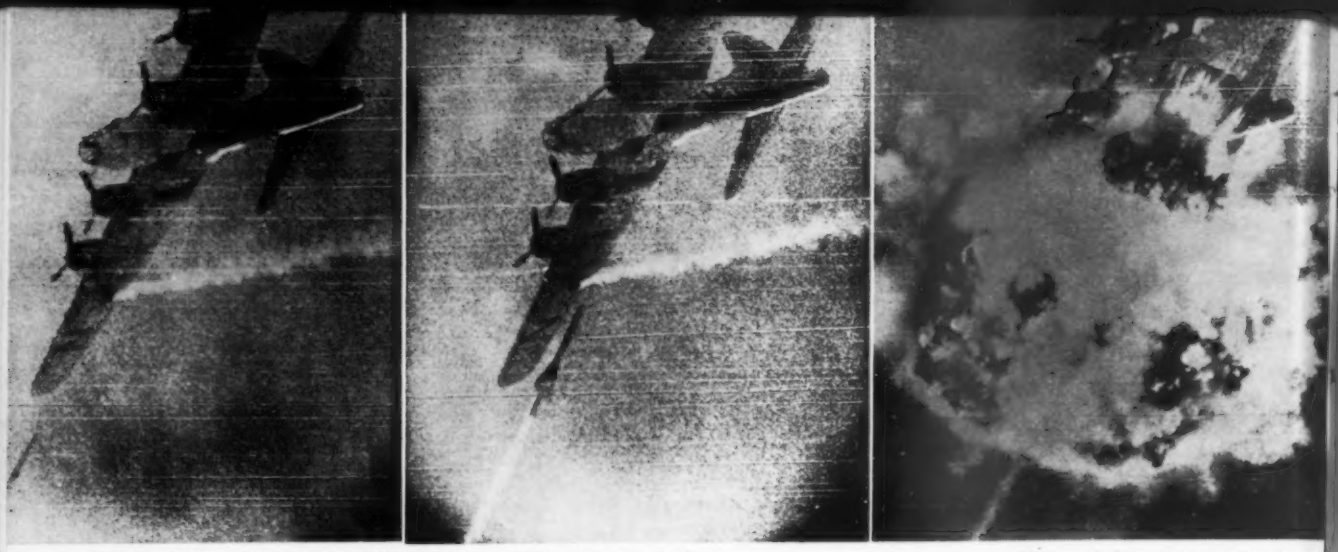
Top missile test facilities are:

Air Force—Air Force Missile Test Center at Patrick AFB, Cocoa, Fla., and Holloman Air Development Center, Holloman AFB, N. M.

Navy—Air Missile Test Center at Point Mugu, Calif., Ordnance Test Station, Inyokern, Calif., and Ordnance Missile Test Facility, White Sands Proving Ground, Las Cruces, N. M.

Army—White Sands Proving Ground at Las Cruces, N. M., and Redstone Arsenal, Huntsville, Ala.

• • •



In dramatic firing tests photos, Nike missile approaches the target plane.

Nike explodes on impact, its fiery

THE ROLE OF THE MISSILE

THE MISSILE is a weapon of war and the role of the missile must be dictated by the nature of the war to be fought. The significant picture of the missile which is emerging from scientific research, military analysis, and practical field tests is the versatility of the new vehicle.

General Twining expressed this versatility in a limited way in his statement (*below*) describing the "long and delicate transition" which the USAF is now making from planes to missiles for some of its missions.

The Navy might add that missiles will be launched from aircraft carriers to ward off attacking fighters or to shoot down offensive missiles, launched from planes to disable shore installations, launched from helicopters and other submarine patrol planes to seek out submerged submarines, launched from submerged or surfaced submarines to attack surface installations.

The Army can add its own unique list.

"Instantaneous retaliation"

Essentially the missile is a time machine—a vehicle which will give both offensive and defensive armies a strange new relationship. The country which best realizes these relationships, and in the event of hostilities uses them to advantage, will win.

To the U. S. policy of preventing war by the threat of "massive retaliation," the missile adds the significant aspect of "instantaneous retaliation." If the U. S. policy simply meant "If attacked we will fight back," it would be of little significance.

It means essentially we will fight a thermo-nuclear war. And the intercontinental ballistics missile adds to this threat the time factor made possible only by missiles. Translated it means that within 30 minutes of the first realization of war, missiles with hydrogen warheads will level the war-making potential of the enemy.

Intercontinental missiles

To do this would require an intercontinental missile which could travel from U. S. bases to the heart of Russia at speeds of at least 10,000 miles per hour. (The V-2 of World War II vintage traveled 5,000 miles per hour over short ranges.) The development of a 10,000 mph missile which would be able to strike 5,000 miles away in Moscow in half an hour is an ultimate goal.

Prototypes of intercontinental missiles are now flying, according to Senator Stuart Symington. By these, the former Air Force Secretary undoubtedly refers to the Northrop Snark and the North American Navaho. These are worthy forerunners of the ultimate intercontinental missile. Their main shortcoming is relatively low flight speeds, matching those of current bomber types.

The warheads of any of these intercontinental missiles would not only obliterate an area measured in miles, but would also saturate that area with residual radio-activity, more deadly than the blast. Such radio-activity, lingering long after the explosion, leaves an area uninhabitable until expensive and time-consuming decontamination has been performed.

Defensively the retaliatory measure becomes a shield when it appears that offensive weapons have too sharp an edge. The threat of the newest weapons can best be met by being in a position to deliver in kind, until an absolute defense is established.

Future wars

U. S. military planners must assume that any future war will start with a massive assault, with both planes and missiles, on allied strongholds in Europe and the U. S. Missiles offer the only real promise of intercepting the initial assault. More important, they offer the promise of instantaneous action against the bases from which successive assaults might otherwise be launched.

This country is committed to mutual defense activities on a worldwide scale including heavy commitments in Europe. A surprise Russian

"Missiles will be launched from airplanes as well as against airplanes and planes will be used to find and attack missiles while missiles are being used to find and attack planes. The mobile and defensive capabilities of airplanes will be integrated with the more static defensive and offensive capabilities of missiles."—GEN. NATHAN F. TWINING, *Chief of Staff, U. S. Air Force.*

fragments ripping the target apart.

Wing shattered and afire, plane starts final plunge as an engine rips loose.

onslaught would wipe out key bases, hundreds of planes, and thousands of trained crews and technicians. While field commanders try to regroup, subsequent and conclusive attacks might be launched.

Missiles can turn the tide. Missile installations can be widely dispersed. Groups of two, three or four launchers can be set up virtually anywhere. Attempts to seek out and destroy multiple missile installations, unlike air fields loaded with aircraft, would price any country out of the war.

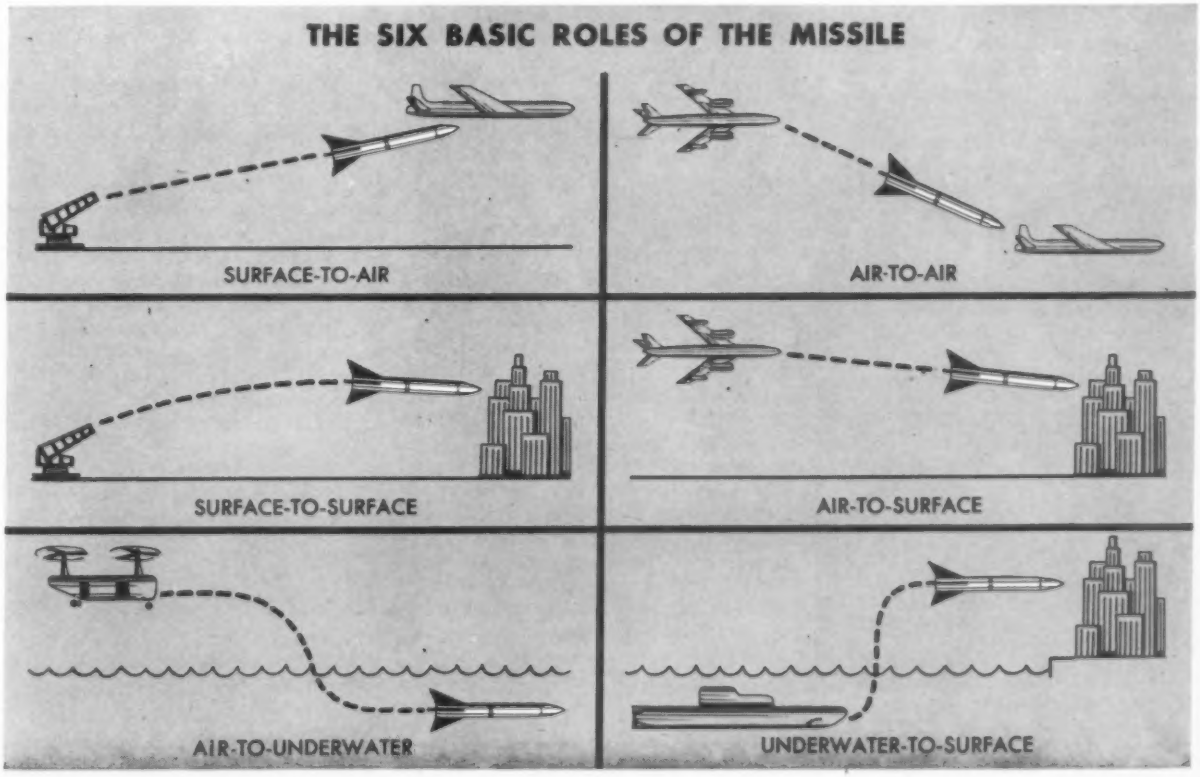
Missile batteries can wipe out enemy air fields, installations, and power stations, disrupt all forms of transportation, and generally play havoc with the enemy's ability to follow up on his initial attack.

This is it!

This is the time so vital to the field commanders. It provides the only breathing spell possible during which to knit together surviving elements of his defensive and offensive machine.

It is this role which is filled by the surface-to-surface missile. In Europe there are already two squadrons of Martin B-61 Matadors suitable for such service. This is but a token start, but the program is under way. It is significant that at that time U. S. based intercontinental missiles could be called into "front line" action in a matter of hours—no rounding up of crews, familiarization, or complex logistics. Just the decision: "This is it."

With the proper early warning radar system, whether earth bound or



Ryan's Firebee, a drone with missile potential, is launched from a mother plane.

airborne in picket planes, surface-to-air missiles such as the Nike and the Terrier might minimize or defeat the initial onslaught. The success of defensive missiles in intercepting supersonic offensive missiles is still a matter of conjecture revolving around the questions: how many, how high, and how fast?

The numbers game

Each of these questions is being approached from a different angle. Accuracy of missile guidance is the most obvious. The goal is one kill for one missile. It hardly approaches this level today—perhaps two kills for three missiles. But this trend is one of steady improvement. It is only a matter of time.

Numerical superiority is another. If each missile knocks out one missile or plane the enemy must launch more carriers than there are missile launchers, including an allowance for multiple firings from one launcher.

This dictates the need for multiple surface-to-air installations around every potential target of importance. It demands the earliest possible warning so that enemy aircraft may be intercepted well away from the target and so that two or more missiles may be fired in succession, at the same target if necessary, or at separate targets if possible.

These surface-to-air missiles, or air-to-air missiles if the tactical situation permits their use at this stage, are relatively inexpensive—$20,000 each. By comparison the long range offensive weapon of the aggressor would be an expensive carrier plus the highly expensive nuclear warhead scheduled for this type application.

Convair's Terrier, shown in this artist's view, parallels the role of the Nike.

This cost relationship is, of course, reversed when we are sending missiles with hydrogen warheads to the enemy's installations. And here the constant struggle for maximum speed and altitude, ever more fantastic, is apparent. The ratio of hits to misses is going to spell the terms of victory. Any slight improvement may spell the difference between success or failure.

It is worth considering the role of the fighter interceptor planes during this crucial initial onslaught, when the first warning of danger is only minutes or even seconds ahead of the attack. Ideally, if our warning system is adequate, fighter planes might get one or two passes at the missile before counter missiles are fired. The odds against this fighter/missile engagement are raised by the high operating altitude of the long range missiles, their tremendous speeds compared with piloted aircraft, and general maneuverability problems.

Martin's Matador, one of a series of surface-to-surface missiles, is seeing squadron service in Europe.

For this reason the pilotless fighter of the Boeing F99 Bomarc category is most promising. Used as a conventional surface-to-air missile, it is a long range, high altitude interceptor which will find its target and destroy it. Pilotless fighters may someday carry their own air-to-air missiles. Such fighters could be launched with the facility of regular missiles, using rocket assist take-off, get the advantage of acceleration and climb not possible in piloted planes, and carry enough air-to-air missiles to handle numerous invading vehicles.

Eventually this might be practical with a recoverable missile, one that can carry its short range, air-to-air missiles or guided rockets to the airborne target area, release them, and make its way back to a reloading station. Possibly a parachute recovery system such as used so successfully on the Ryan Firebee could be utilized or, if conditions permit, a controlled return to a flying field accomplished.

But if the piloted fighter interceptor

Douglas' Honest John, caught as it leaves the launcher, is an Army unguided, artillery rocket.

proves itself capable of entering what might otherwise be missile-to-missile warfare, it will be largely by the aid of missiles. One of the biggest groups of missiles under development today is the air-to-air group which involves at least eight versions of three different types including the Sperry Sparrow, the Hughes Falcon, and the Philco Sidewinder.

Matching the missile

These missiles, which serve as highly refined ammunition for the fighter, are extensions of conventional rockets and cannons. Recently the Air Force changed the Falcon designation from the F-98 to GAR-1, meaning guided air rocket. Because it has no recoil, as do heavy cannons, the missile can show the way to lighter fighter planes which will in part serve to improve general plane performance toward the goal of matching it to missiles.

The other major category of USAF missile which will probably see service not in the initial onslaught but in the second wave of "massive retaliation," the wave following the intercontinental missile, is the air-to-surface missile. Our most advanced bomber designs carry air-to-surface missiles which go a long way toward changing the role of the bomber.

The Bell Rascal is a promising missile in this category. It will permit bombers, or for that matter long range fighters, to carry a thermo-nuclear weapon into enemy territory at extremely high altitude and speed to within a few hundred miles of the target. At altitudes and distances which provide the mother plane with ample protection against detection, or at least interception, the missile can be launched. It may home on or be guided to the target.

Chance Vought Regulus, the Navy's prime surface-to-surface missile, takes off from shipboard. It has also been launched from a submarine.

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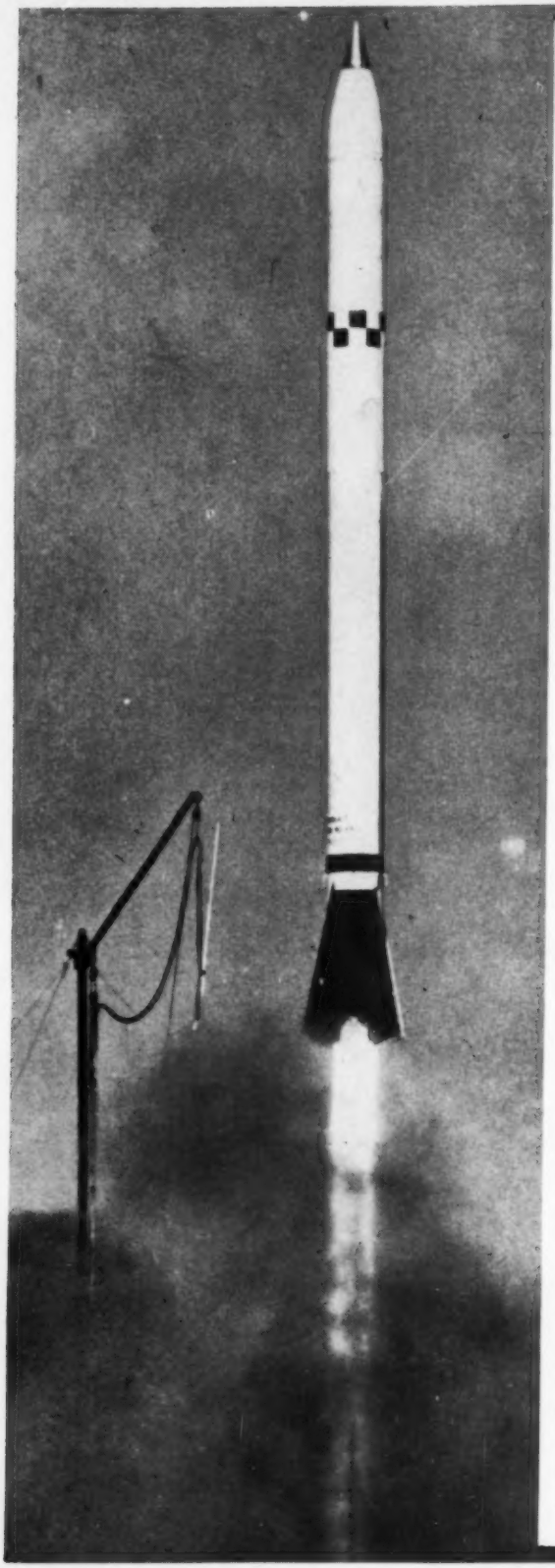
AMERICA'S MISSILE ARSENAL



The Surface-to-Surface Corporal

Manufacturer	Missile	Designation	Agency
Bendix	Loki		Army
Chrysler	Redstone		Army
General Electric	Hermes		Army
Boeing	Bomarc	F-99	USAF
Oerlikon (Swiss)	MX 1868		USAF
Western Electric	Nike I	XSAM-A-7	Army
Western Electric	Nike B		Army
Bendix	Talos	XSAM-N-6	Navy
Bendix	Talos-W	XSAM-N-6	Navy
Bendix	Talos-L		USAF
Convair	Terrier	XSAM-N-7	Navy
Martin	Matador III		USAF
Raytheon	Hawk	XSAM	Army
Cornell Aero Lab.	Lacrosse		Army
Convair	Atlas		USAF
Douglas	Honest John		Army
North American	Navaho		USAF
Firestone	Corporal	XSSM-A-17	Army
Martin	Matador I	B-61	USAF
Martin	Matador II		USAF
Chance Vought	Regulus I	XSSM-N-8	Navy
Chance Vought	Regulus II	XSSM-N-8A	Navy
Northrop	Snark	B-62	USAF
Fairchild	Petrel	XAUM-N-2	Navy
Eastman Kodak	Dove	XASM-N-4	Navy
Sperry	Sparrow I	XAAM-N-2	Navy
Douglas	Sparrow II	XAAM-N-3	Navy
Raytheon	Sparrow V		Navy
Hughes	Falcon I	F-98 GAR-1	USAF
Hughes	Falcon II	F-98	USAF
Hughes	Falcon III	F-98	USAF
Philco	Sidewinder I	XAAM-N-7	Navy
Philco	Sidewinder II		
Fairchild	Gorgon V	XASM-N-5	Navy
Bell	Rascal (B-63)		USAF

Code: L.P.—liquid propellant. S.P.—solid propella

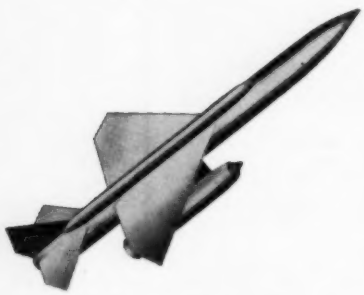
With approximately three-fourths of ... without missiles. The Chance Vought ... suggest that since guided missiles are

Powerplant	Range	Length	Dia.	Wing Span	Gross. Wt.	Comments
Surface-to-Air Missiles						
Rocket, S.P., Grand Central		6′	3′			Unguided. Based on German Taifun barrage missile. Finned body.
North American L.P. Rocket						Production by Chrysler under technical cognizance of Redstone Arsenal.
Rocket, G.E.		25.7′	32″	see comment	8-12,000	Project advanced through R&D with V-2, Bumper, A-1, B, C-1 missiles. Work reported continuing on very advanced type of missile. Some with 7½′ cruciform wings & fins.
Marquardt Ramjets plus Rocket	100+	See drawing				Based on Gapa. Delta wing. Supersonic.
Rocket L.P.	12	16′	3′-5″	4′-3″	545	Under evaluation by USAF. Designed by Oerlikon in Switzerland but may be produced by Oerlikon Tool and Arms Corp. of America. Top altitude, 66,000 ft. Beam rider guidance.
Rocket L.P., Bell	25	20′			1000	Delta-winged. Assembled by Douglas under sub-contract to Western Electric which produces the guidance system. For continental defense.
Booster-Hercules Powder, S.P.	50	25′				Much larger version of Nike I
McDonnell Ramjet plus Rocket McDonnell Ramjet						Bendix design airframe & ramjet being built by McDonnell under sub-contract.
McDonnell Ramjet						
Rocket, S.P. Allegheny Ballistics	10	14.75′	1.0	4′	3000	Finned body, produced at Pomona. Guidance by Bendix.
		30′	4.5			Experimental SAM based on SSM Matador I.
	50					A low-altitude missile to supplement the Nike.
Surface-to-Surface Missiles						
Piston Engine	8					275 being bought fiscal year '55. Developed by Army Ordnance for Marine close support. Winged. Subcontracted to Hastings Instr. Co., Va. Modified Fairchild Lark.
Rocket,	Inter.					Intercontinental missile.
Hercules Powder Co., S.P.		27′-3″	30″		6000	Artillery Rocket—Emerson Electric is second source. Unguided.
Ramjet, Wright Aero.	Inter.					Intercontinental.
Rocket, Ryan		40′	2.5′		11.000	Radio guidance.
Turbojet, Allison J-33	500+	30.0′	4.5′	28′-6″	15.000	Two squadrons in Europe.
		30.0′	4.5′	28′-6″	15.000	Larger unidentified eng., higher speed, greater range.
Turbojet, Allison J-33	500+	32.0′	4.5′	21′	14.500	Subsonic. Bendix radio guidance system.
Turbojet, Allison J-71	Inter.	32.0′	4.0′			A winged missile.
Air-to-Underwater Missiles						
Turbojet, Fairchild J-44						Initial design work by National Bureau of Standards. Produced at Wyandanch, L. I. To be launched from Bell HSL Helicopter.
Air-to-Air Missiles						
Rocket, S.P.	5	8.2′	.42′		300	Sperry design for which Douglas has built all airframes. Versions differ primarily in guidance systems. Folding fins for easy shipment & storage. In production at Sperry-Farragut plant, Bristol, Tenn.
Rocket, S.P.	5	8.2′	.42′		300	
Rocket, S.P.	5	8.2′	.42′		300	
Rocket, S.P.						Extensive use of reinforced plastic in body and wings. Philco is second source.
						Primary difference from Falcon I is in guidance system.
						Developed by Navy Ordnance at Inyokern, Calif.
Air-to-Surface Missiles						
			33″(max.)			Limited production, glide-type missile. Shear-type wing. Limited production.
Rocket, L.P., Bell Aircraft	100					Based on X-1 aircraft. May have designation changed Bell also has guidance system. Supersonic.

Inter.—intercontinental.

With approximately three-fourths of the world's surface water, the Navy has a battlefield too large to work with less than the best. The Navy's missile program is very active, both in the Bureau of Aeronautics where aviation requirements are met and in the Bureau of Ordnance where a missile is just a piece of artillery.

Navy requirements overlap both Air Force and Army needs. Certainly the surface-to-air missile offers one of the few apparent solutions to protecting aircraft carriers and other key ships from enemy air attacks. In this class falls the Convair Terrier, which is being built in one of the country's biggest missile production plants at Pomona, Calif.



The Surface-to-air Bomarc

But the role of the carrier is to carry the battle to the enemy and in this basic role it has the Chance Vought Regulus surface-to-surface missile. Current production models of this missile are subsonic. The Regulus has been one of the Navy's most valuable missile test vehicles since many of them, with conventional landing gears have gathered a wealth of data on missile behavior for all services.

A unique tool of the Navy in its role of keeping control of the sea is the Fairchild Petrel, an air-to-underwater missile. Indications are that the relatively secured Eastman Kodak Dove also serves the roles of air-to-underwater missile.

The Navy's submarine fleet is not without missiles. The Chance Vought Regulus has been launched from the deck of a submarine. This required a surfaced submarine and may or may not have practical applications because of the large size of the Regulus and the unavailability of stowage space on present day submarines. More compact missiles, including possibly an extension of regular torpedoes, may extend this role to underwater-to-surface or air missiles at a later date. The Navy has official designations for such vehicles.

All these applications stress one thing: the missile's versatility. The missile is simply a vehicle. To restrict it to one service would be like restricting the use of the wheel to one service. Each of the services, fulfilling its assigned duties, wants and deserves missiles. The lines of demarcation are less clear with missiles than with most vehicles, but much is being done *(see page 38)* to clarify the problem.

The Army, which sponsored the Nike development, has recently had its role in missile activities more closely defined. This still leaves room for such basic surface-to-surface Army missiles as the Firestone Corporal and Douglas Honest John.

Through the Army's development program, even the Marine Corps is in the missile picture with Cornell Laboratory's LaCrosse, a close support missile of about eight miles' range.

These manyfold applications by each of the services contemplate a gradual transition. As Rear Admiral Charles Horne (Ret.), general manager of Convair's Pomona Div., has said: "The fact that dependable guided missiles are becoming available to the armed forces sets up a course of action without precedent. Historically, no weapons system has ever been replaced by a new one in time of peace.

"It is in the nature of military men that they cannot put their complete trust in a weapons system that has not been proved in combat. And they are quite right in their attitude. It is ridiculous to suggest that since guided missiles are becoming available, the guns and bombers should be scrapped.

"No matter how good they look on paper, and in field tests, guided missiles cannot *now* supplant the proven weapons of warfare.

"Rather, guided missiles will be introduced gradually into operating doctrine as complementary weapons systems. The remaining problems of production, training, and doctrine will be worked out—in an orderly way—as rapidly as possible."

"Guided missiles will not cause an overnight revolution in how America defends itself, unless the conditions of an actual war precipitate the change."

But even in its present state of development, the missile has become an essential part of the military system, supplementing and complementing existing weapons. The transition period now taking place is reflected industrially as well as militarily *(see page 50)*. Increasing numbers of companies hitherto unassociated with military production are coming into the missile picture.

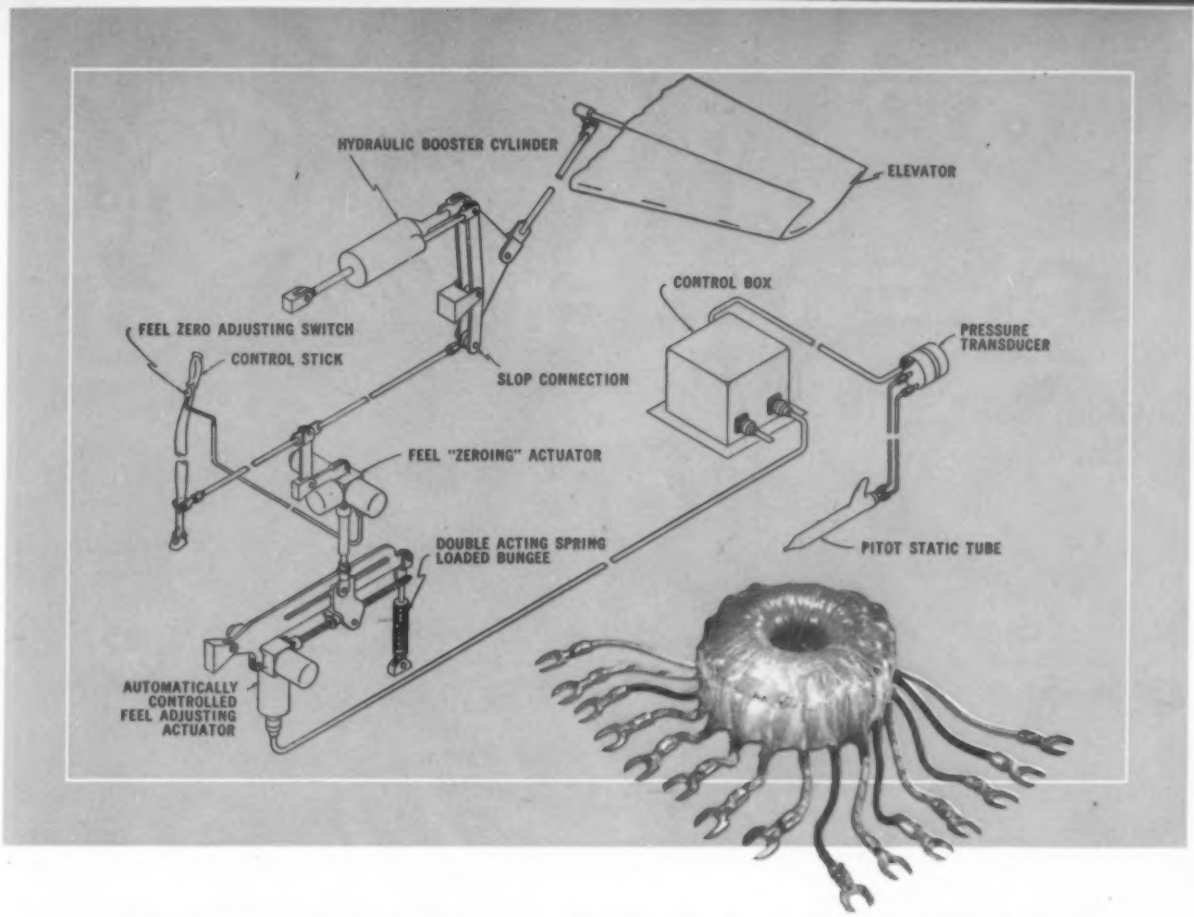
Despite all that a missile can do, or is intended to do, it is not and probably never will be, all things for all services. Missiles are extensions—adjuncts—of weapons and methods of waging war which, terrible though they be, are subject to imperfections and to being overtaken. The role of the missile is not to develop a Maginot Line philosopy under which this nation relaxes and becomes vulnerable. Rather, it emphasizes the need for further research and development in the weapons improvement process.

Within the armed services, particularly the Air Force, the advent of the missile is causing fundamental and widespread changes in many areas. Being in most cases an expendable item, it carries no operational crew and requires no overhaul facilities and only a minimum of maintenance while waiting in readiness for use. Thus the missile reduces operational crews, overhaul and maintenance personnel, and workshops, with related cuts in training programs and establishments.

If these gains and losses are translated into money, it can be clearly seen that the missile has an important effect on the military budget—some sections can be reduced while others must be increased. The main factor in the economics of the missile, however, is that it is a "one-shot" expendable article. Since missiles are being developed which, even with large production runs, will cost millions of dollars each, the financial angle is important in seeking to establish the role of the missile. • • •

The air-to-air sparrow mounted under the wings

The surface-to-air Oerlikon



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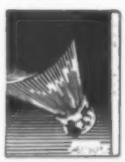

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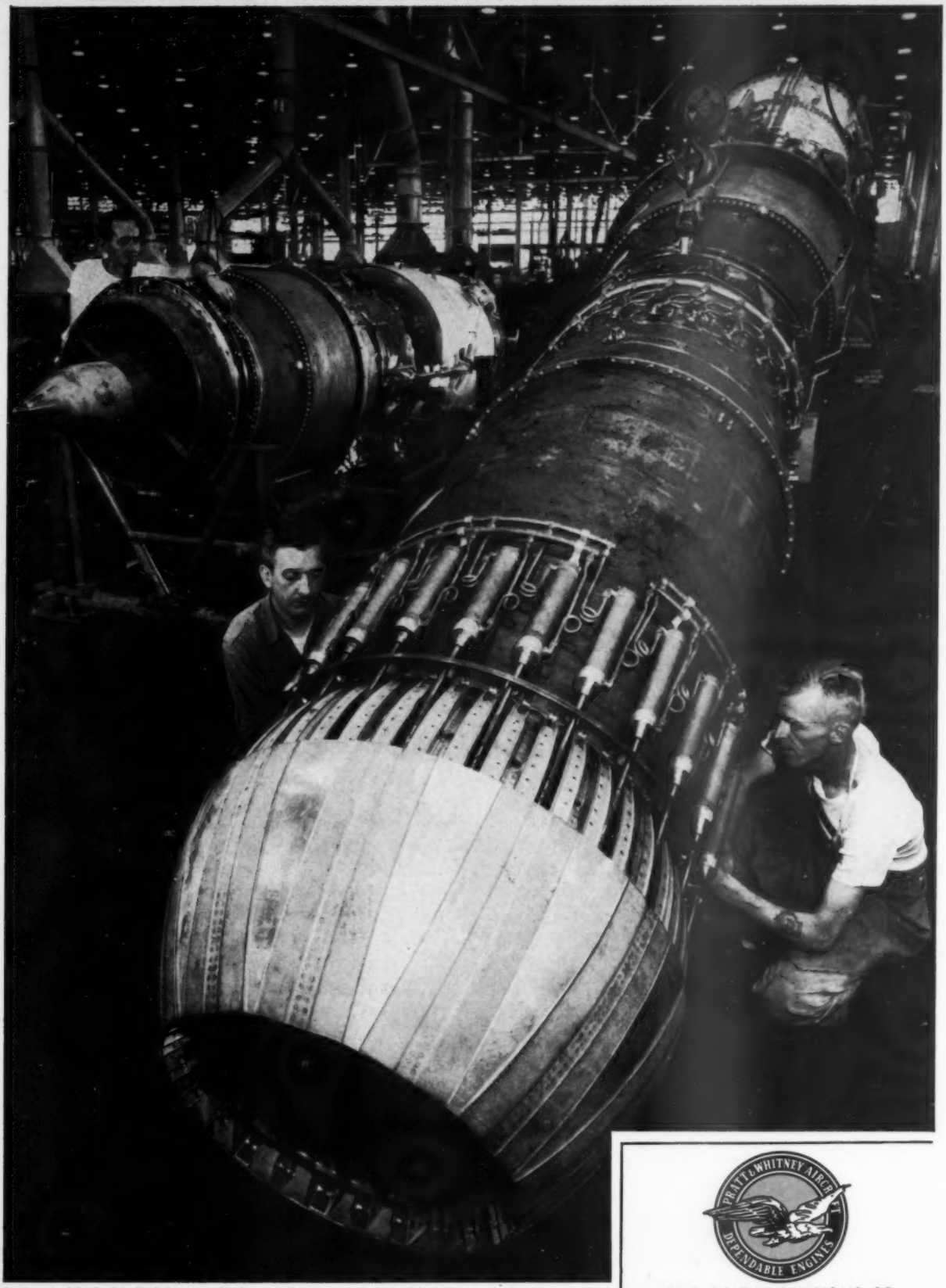

Power behind the F4D's superlative performance is provided by one 10,000-pound thrust class Pratt & Whitney Aircraft J-57 turbojet, equipped with afterburner for short periods of huge additional power.

The sleek Douglas F4D is the latest carrier-based interceptor and the Navy's first combat aircraft to outspeed sound in level flight. Production airplanes, now coming from the Douglas El Segundo plant, are powered by Pratt & Whitney Aircraft's J-57 engines.

Skyray has High Performance with J-57 Power Plant

When it comes to interceptor performance, few combat planes can match the Douglas F4D Skyray, one of the aircraft bringing a new potency to Navy carrier aviation.

The Pratt & Whitney-powered Skyray is the Navy's first supersonic combat airplane, and one of the fastest aircraft in the world. Its rate of climb and many abilities at design altitude are unique among fighter aircraft. It is in production and scheduled for service with the Fleet in 1955.

In the Skyray, and in other combat airplanes, performance of Pratt & Whitney Aircraft's J-57 turbojet is fully justifying the long years and intensive effort required for its development and production.

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MISSILES AND THE AIRCRAFT INDUSTRY

"If you want to stay on top in this business now, you're going to have to get into missile work," says a manufacturer.

MISSILE DEVELOPMENT has an A-1 priority in the aircraft industry today.

The Defense Department now is spending as much money on guided missiles research and development as on aircraft research and development. This will be reflected in future allocations of production funds.

More than one manufacturer's projected income curve shows missile income coming along, or anticipated, to offset diminishing aircraft revenues.

"If you want to stay on top in this business now, you're going to have to get into missile work," observed an executive of a west coast aircraft accessory manufacturer.

As far as the aircraft industry is concerned, the guided missile has now advanced from the research to the development stage. The wild blue yonder days are past. The approach to missile design has become a straight engineering approach. There are no mysteries about it.

Research will keep going

"There's no difference between designing a missile and designing a high-performance aircraft," is the way Elmer P. Wheaton, chief missiles project engineer at Douglas-Santa Monica, puts it.

This is not meant to imply there is no more room for pure research or that the Ph.D.'s, the physicists, and the scientists are on their way out. Research will keep going forward on missiles as it has on aircraft, and there are certain avenues where it may be said there is much room for improvement. Electronics still has a long way to go. But the problems have been defined and the techniques established and when the Defense Department comes along with a requirement the aircraft industry knows how to go about doing the job.

Rapid missile progress has been achieved in the aircraft industry primarily because its people are old hands at dealing with systems.

"The missile is strictly a systems business," says R. C. Sebold, vice president-engineering of Convair.

It's significant that the ordnance sections of both the Army and the Navy went outside their own circles and awarded their two biggest missile contracts to two airframe manufacturers rather than to projectile makers or manufacturers experienced in volume production of other types of products.

One of these contracts is Convair's operation of the $50,000,000 Navy facility at Pomona, Calif., where the anti-aircraft Terrier is being produced for the Bureau of Ordnance.

The other is Douglas-Santa Monica's contract to assemble Army Ordnance's anti-aircraft defense missile, the now famous Nike. Technically, Douglas is a sub-contractor to Western Electric, which makes the Nike guidance package, but actually its responsibility is little different from what it would be if it had complete systems management. All other sub-contractors engaged in making parts or components of the Nike system come under Douglas. Moreover, Douglas also has been selected to operate the second-source plant which Army Ordnance is now getting up at Charlotte, N. C.

While the aircraft industry has demonstrated it is best equipped to do a superior job of systems management in the shop, it encounters some trouble on the financial side. This is because the heavy side of the cost of a missile is in its electronics. It makes it difficult to spread the short end of the missile dollar out over all the administrative, engineering, and other systems management costs and come out ahead. It becomes doubly difficult when a development contract for the design and production of a new missile involves only a limited number of prototypes and then, if the missile is a success, the production contract is thrown open to new bids. Thus the contract may be gobbled up by another company which had no part in the original development.

Missiles have most of the problems of aircraft, plus a few of their own. Topping all problems is reliability. You have to work out the "bugs" in missiles the same as you do in aircraft. Only it's harder to do and it costs more. In testing an aircraft you have a man along to help you record the score. You can shoot only so many missiles before you go broke. Fortunately, there are ways to short-cut. You can start in, for example, on the "bugs" in your guidance system by installing it first in a piloted airplane.

Supersonic aerodynamics was a totally new and unexplored field when the aircraft makers began venturing in this new area of design. New wind tunnels and other technological advances are simplifying the aerodynamic design problem, but it's still tougher than aircraft. Missiles also take more engineering and add up more engineering time, particularly in the analytical field.

In contrast to aircraft engineering, where the pattern is pretty well set and you can rather accurately measure the ratio of board-hours and analytical time, missiles require few board-hours, but very high volumes of analysis. Shortly after Douglas installed its big IBM Model 701 electronic data processing machine at Santa Monica, 80% of its time was being monopolized in solving analytical problems on missiles.

Terrific Impact

The V-1 buzz bomb and the V-2 ballistic rocket demonstrated the great potentialities of the missile to the aircraft industry in this country. There were earlier efforts. As a matter of fact, Douglas, which was the first aircraft manufacturer to begin explorations in this field, went to work on a National Defense Research Council contract even before World War II. This happened in 1941. But 1946 was the year when organized programs of development were started.

Impact on the aircraft industry was tremendous. It also was confusing. Objectives are clearer now—such as the proper relationship between missiles and piloted aircraft. Many made the early basic mistake of looking upon the missile as a replacement for the piloted aircraft. One of these days this may happen, but, if so, it's a long way off, and piloted aircraft will continue to be an integrated part of the national defense. Meanwhile, missiles will fulfill their own important functions.

As might be expected, organizational approaches to missile development vary widely among companies. Northrop Aircraft, for example, got into the business early in the game when Jack Northrop was president of the company and the active head of its engineering and add up more engineer-intercontinental B-62 Snark was absorbed by the Hawthorne manufacturer's established engineering department.

No organizational changes were made in pursuing further development of the Snark under Edgar Schmued

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Side by side, they roll off the Fairchild production lines – the famed C-119 *Flying Boxcar* and its new assembly line mate, the C-123 *Avitruc.*

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Speed Control Division, Wickliffe, Ohio

same goes for other missile work at Northrop. Similarly, missile activity which originated at Northrop's Radioplane division remains within that division.

On the other hand, Lockheed chose to establish a wholly different and autonomous division when it decided the time had come to expand its original test vehicle projects into a broad-scale missile operation. It's called the Missile Systems Division and makes the third complete division in Lockheed's corporate setup. The other two are the California Division and the Georgia Division. It's headed by Elwood R. Quesada with the title of vice president and general manager.

Convair plays both sides of this record. It has a separate division devoted solely to missile production. This is the Charles F. Horne-headed Pomona Division which produces the Navy Terrier and also works on the development of other missile projects. But still other missiles are assigned to Convair's San Diego Division.

Boeing, Convair, Northrop, and North American are examples of airframe manufacturers that have branched out into direct work in electronics in developing automatic navigation control equipment for missiles of their own design. Convair has approximately 750 electronic engineers in its laboratory at San Diego and engages in a wide range of research in its complex field. Its lab has even done work for organizations like the Bell Laboratories in some categories where it has reached high efficiencies. Northrop adds up to 850 in its electrical and electronic engineering group.

North American, which takes no little pride in being able to make the point in its advertising that it has built more airplanes than any other company in the world, illustrates how far an airframe manufacturer may extend its sphere of activity under the impetus of new technical developments.

At the start of its 1947 fiscal year, North American had 170 employees in the aerophysics section of its engineering division. These were the workers conducting research programs on guided missiles, rocket propulsion, and supersonic aerodynamics. Things have been happening rapidly since.

North American's MACE

This modest engineering section has grown into what North American calls its missile and control equipment (MACE) operation. It encompasses 5000 scientists, engineers, and technicians plus another 5000 affiliated workers—or a total payroll of 10,000. Its field laboratory in the Santa Susana mountains near Los Angeles is the largest integrated test facility of this type in the world. It's rocket engines are whoppers, too. They develop power in the millions of horsepower. Not all for missiles, but mostly.

Douglas has the distinction of having the biggest missile backlog in the business. It's in production on three missiles—the heavy-volume Nike, another Army Ordnance missile called the Honest John, and the Air Force air-to-air Sparrow.

Douglas also has stuck closer to home base in the area of its missile activities than some of the other companies. It has made no attempt to enter into electronics production or into other components of the system. This is in keeping with the Douglas tradition of not getting into competition with its suppliers.

It's also noteworthy that Douglas centers its missile activities in its Santa Monica Division, where its commercial transports are designed and built. Like missiles, commercial transports put a premium on sound systems management. • • •

THESE MEN DIRECT THE MISSILE ACTIVITIES OF THE "BIG FIVE"

Southern California is a hotbed of missile activity. But the "big five" aircraft manufacturers dominate the scene, a natural outgrowth of the specialized talents of the aviation industry. The men directing the missile activities of these companies provide an interesting cross section of management and engineering talent:


Wheaton

Elmer P. Wheaton, chief missiles project engineer at Douglas Aircraft Co. became identified with missiles in 1943 following his appointment as assistant head of the company's research group. He joined Douglas in 1934, worked in production control, as a draftsman in engineering, and director of flight test instrumentation. He pioneered strain gauge applications in his work with the B-19 and DC-4E. Wheaton is currently chairman of AIA's guided missile committee.


Waite

L. L. Waite, v.p. for missile and control equipment at North American Aviation, has jurisdiction over design development and construction of selected equipment for long-range missiles, advance work in nuclear physics, and allied activities. He joined North American in 1940 after serving as assistant chief engineer for McDonnell. Prior to that he was assistant project engineer for The Glenn L. Martin Co.


Schmued

Edgar Schmued, vice president of engineering at Northrop Aircraft, joined that company in 1952 after 22 years as chief designer and assistant chief engineer of North American. He is recognized as one of the company's leading designers. The engineering team he has assembled at Northrop is also the missile design team. There are no lines of demarcation.


Horne

Charles F. Horne is manager of Convair's Pomona Division, sometimes called the guided missiles division. A retired admiral, Horne's last Navy post was as deputy chief, Naval Communications from 1946 through 1948. At that time he joined CAA as acting director of the Federal Airways Div. In 1951 he was appointed CAA Administrator, a post he held until joining Convair. He holds a master of science degree in communications and electronics from Harvard University.


Quesada

Elwood R. Quesada, vice president and general manager of Lockheed Aircraft Corp.'s missile system division, is a retired USAF general who joined Lockheed in 1953. His military career included command of the first thermo-nuclear experiment at Eniwetok. Quesada, who joined the service in 1924 as a flight cadet, commanded the 9th and 12th fighter commands, was special assistant to the chief of staff in 1948, and later was chairman of the joint technical planning committee of the JCS.

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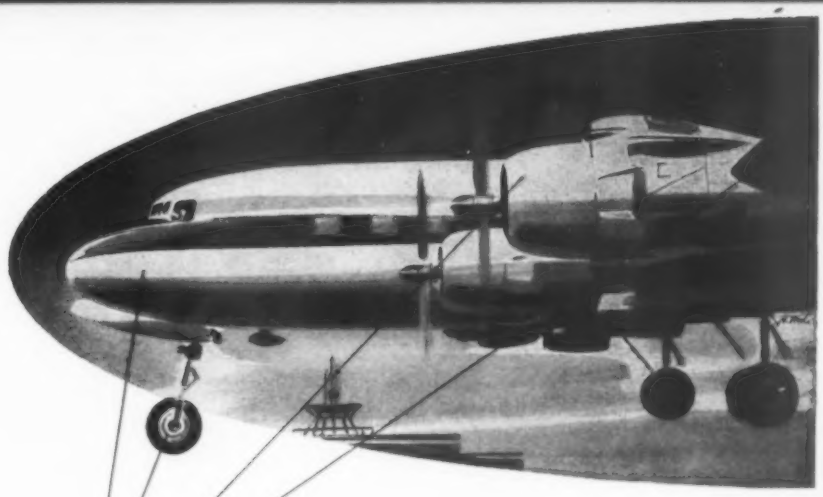

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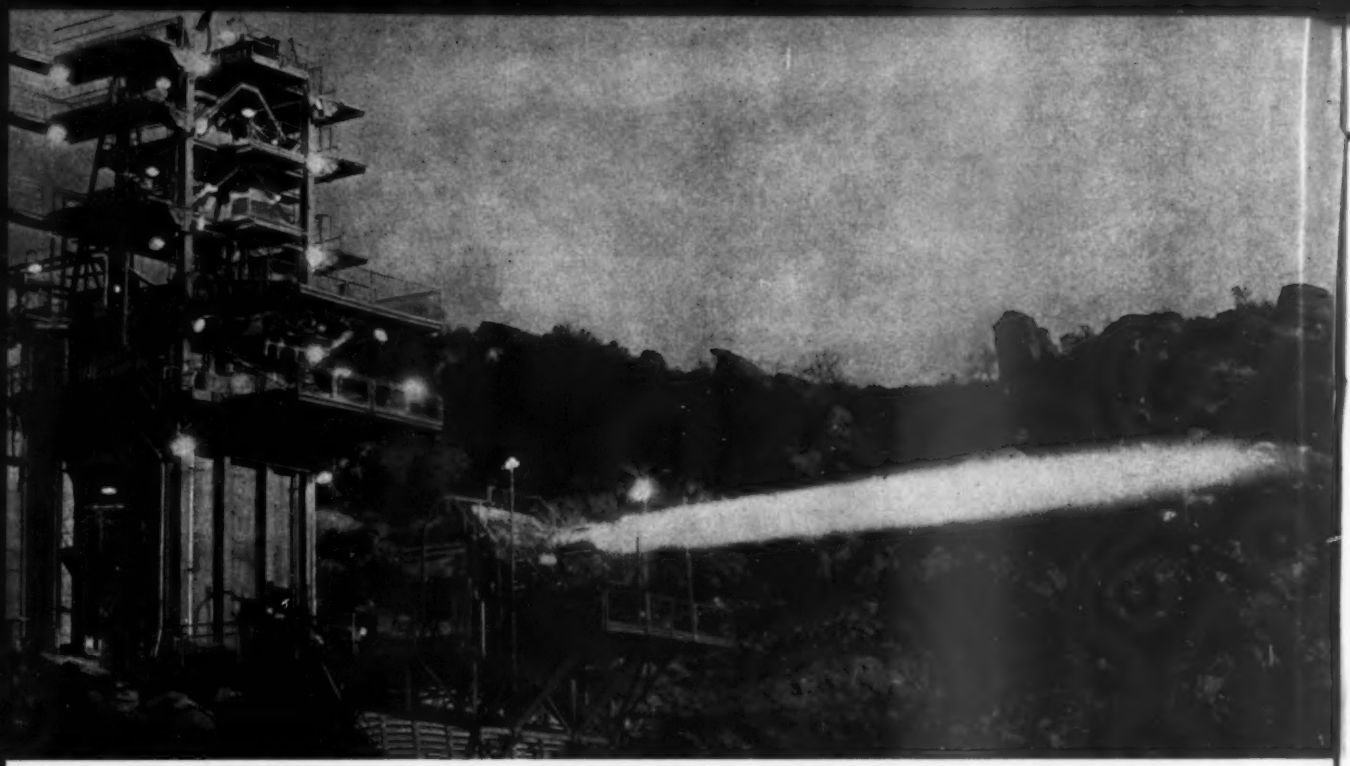


High in the Santa Susana Mountains near Los Angeles, a North American liquid propellant rocket engine is shown being put through its paces.

MISSILE TECHNOLOGY—PART 1

THE POWER OF THE MISSILE

THE goal of both Russia and the United States is the development of an intercontinental missile carrying a sizeable thermo-nuclear warhead. Geographical considerations dictate that this missile have 5000 miles range and the reality of defensive armaments makes high supersonic speeds equally basic.

Such a vehicle will require about one-half million pounds of thrust. This compares with 10,000 pounds thrust in our finest supersonic fighters. Because of its high operating-altitude requirements, well outside the earth's atmosphere, the engine will initially be a liquid propellant rocket. At this stage in rocket engine development such an engine costs about one dollar per pound of thrust.

But the demand of the missile is not purely one of high thrust and high altitude. Vital missiles meeting many tactical requirements are powered by turbine engines, solid propellant rockets, and ramjets. The smallest of the group is probably Fairchild's J44 turbojet used in the Fairchild Petrel air-to-underwater missile and in the missile/drone Ryan Firebee. It weighs about 300 pounds and develops 1000 pounds thrust.

Security cloaking the technical aspects of missile engines is almost directly proportional to the power of the engines. Current technology regarding high-power liquid rocket engines is effectively secured. That of the ramjet is almost as secret. Stepping down into the high-thrust jets, like Allison's J71 used in the Northrop Snark, things are still tight. But one can have virtually any information about the Allison J33, used in the Martin Matador and Chance Vought Regulus. Solid rocket engine data is relatively difficult to come by.

One of the basic problems facing every engine is heat. High heat values are directly related to high thrusts. Even where low thrust is acceptable, the demands of low engine weight and economic fuel consumption, assuring maximum missile range and payload, force temperatures skyward.

The heat problem

With jet engines the heat problem is represented by temperatures of about 1500-1800 degrees F. In the liquid rocket heat is more apt to be 5000 degrees F. and up. Since designers have plenty of heat problems in jet engines it would appear that the rocket problems are insurmountable.

To a large degree, the problem dictates the only logical course of action. The liquid rocket designer must resort to artificial cooling of some type to keep the heat at the rocket engine nozzle and along the combustion chamber walls within today's metallurgical limitations. Once the decision is made to use regenerative cooling, or some comparable method, the designer is relatively free of temperature problems.

To a lesser extent, through use of film cooling, the advanced ramjet engine has also licked some of the temperature problems. But the solid rocket and turbojet fight a never-ending battle to gain a few degrees allowable temperature in the hot end of the engine.

It's not too difficult to increase power and gain lower specific fuel consumption through high temperatures. But at some point the designer is forced to strategic materials, metals which are scarce and costly, and in wartime might be unavailable.

The trick is in designing engines with low strategic metals content, materials which are easy to work (simplifying mass production), and using fabrication techniques which assure volume production at reasonable costs. The "one

shot" nature of missile applications stresses the economic aspects of missile engine design.

Certainly this is Utopia. But in the areas where the aviation engine industry has had time to work, long strides have been made. The lower power engines which have been in production for long periods—the Fairchild J44 and the Allison J33—are good examples.

Look at the Allison J33. The USAF and Navy have logged more than 2½ million hours flight time on conventional J33 engines in such planes as the Lockheed F-80, F-94, and T-33, as well as in Grumman F9F's. But these were piloted aircraft.

Allison cuts costs

Allison was able to reduce the critical metals content of the J33 by 85% by redesigning it for the short mission (five hour) requirements of the Martin B-61 Matador missile. In doing so the veteran jet engine manufacturer was also able to cut cost by 30%.

Typical of the improvements:

- By developing an aluminum dipping process for inner combustion liners Allison was able to increase allowable temperatures while replacing the standard inconel liner with a low alloy steel unit.
- Experiments proved that aluminum painting and aluminum metal spraying over non-critical alloys provided effective protection, making it possible to use these more plentiful metals in place of all the stainless steel in the combustion section. Even in the ring and tube assembly low carbon steel treated in this way is used.
- Development of a "cast superalloy" (GMR 235) for turbine buckets made possible 100-degree higher temperatures while reducing critical material. This has now been applied to the rest of Allison's jets and turboprops.
- Other improvements included development of a one-piece, cantilevered exhaust cone tailpipe of aluminum-coated, low-carbon steel, design of a new insulation blanket of low-cost asbestos filler with stainless steel wire screen binder, a 50% reduction in the number of studs and bolts joining the compressor and accessories sections (made possible by less stringent maneuver requirements), elimination of screw bushings in aluminum parts, and a major reduction in engine test time.

This gives some idea of what can be done to meet missile demands with existing powerplants. Fairchild Engine Div. met the expendable engine concept of missile design with a completely new engine design in its J44. The J44 has proved its merit in the Ryan Firebee and presumably in the Petrel missile. It is likely to form the basis of the company's new shaft turbine for helicopter applications.

Core of the J44 design is the sheet-metal monocoque shell which carries the structural loads of the engine while serving as a pressure chamber. Unique features dot the engine. The rotor shaft is a seamless tube requiring a minimum of machining. The front compressor housing serves as the oil tank. There is no oil pump, etc. The J44 is only 22 inches in diameter and 72 inches long.

Fairchild officials say such designs are not limited to small engines. A 7000-pound-thrust engine weighing 2000 pounds is quite possible. Such an engine could be built from raw materials weighing less than 2500 pounds —a conversion loss of less than 20%. In a national emergency savings of this magnitude would be extremely valuable.

These are some of the trends marking the jet engine's revolution to meet the specialized needs of the missile. To date, missile engines have not extended into the split compressor variety. The most modern jet in a missile is reportedly the Allison J71 in the Snark intercontinental missile.

The J71 is a 9700-pound-thrust engine of fairly conventional design. It is about 180 inches long, 37 inches in diameter, and weighs just over 3600 pounds. It is characterized by a 10-chamber cannular combustion section, a 16-stage compressor, and a three-stage turbine. Designed for piloted aircraft use, it has been drafted for one of the country's more important missile roles.

Long-range role for J71

Because of its early stage of development it is doubtful if the J71 engine will incorporate many signs of redesign for expendability. It's significance to the long-range role of turbine engines in missiles will be in the area of automatic control for flights of long duration. Combining the known thrust of the J71 and the fuel and payload (warhead) requirements of an intercontinental missile, it is simple to deduce that it must be capable of 8-10 hour flight ranges. Automatic engine control from take-off, through climb to extreme altitude, cruise, and descent over such an extended period is an enormous task. The programing devices used to attain this performance will be significant.

While simplification and producibility mark the trend in turbine engines for missiles, the ramjet engine is moving in the opposite direction. Every ramjet engine designer and producer has learned to hate the words "flying stovepipe," the popular term used to characterize the simplicity of early ramjets.

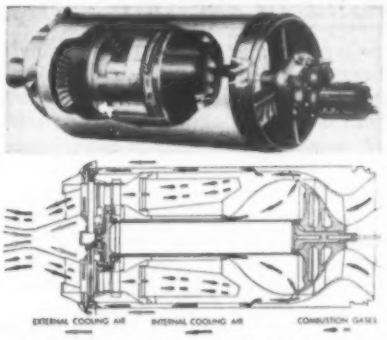
Today's ramjet is a complex piece of machinery. What it lacks in mechanical complexity it makes up in sensitivity to aerodynamic and thermodynamic characteristics.

The ramjet was once a hollow tube or "stovepipe." Moved through the air at speeds near or above the speed of sound, the restrictive action of the tube compressed the air. Fuel was sprayed in and combustion characteristics equivalent to the turbojet engine were achieved without the weight and complexity of mechanical compressors.

Limitations of the ramjet

Inherent limitations in the ramjet are immediately apparent in its demand for high forward speeds before it develops compression and thus becomes a powerplant. This means it must be rocket assisted to attain speed or be carried aloft in a mother vehicle. A delicate transition from supersonic air flow to subsonic flow within the engine is involved to achieve compression and permit combustion. The engine is essentially a narrow-band engine and any variation from design speed and altitude requires compensating changes in engine configuration.

But the rewards are worth it, ac-



New design concept for jet engines is represented in Fairchild's J44. Cutaway illustrates unique structural arrangement while drawing highlights operational aspects.

Monocoque construction of the outer shell of Fairchild's J44 engine, used in the Ryan Firebee and Fairchild Petrel, represents a major development in engines of low critical material content and easy producibility.

cording to ramjet designers. Principally, the ramjet performs a task no other engine can do efficiently—it bridges the vital speed and altitude gap between the conventional jet engine and the rocket. The gap which must be filled is constantly narrowing but is still large. Essentially it appears to be a superior engine type for speeds between 1200-1500 mph and 3000 mph and at altitudes between 60,000 and 80,000 feet.

High-power ramjets are experiencing temperatures of 3500-4000 degrees F. To meet these temperatures, designers have turned to high nickel alloys with cobalt, inconel, etc. Even so it has been found necessary to resort to bleed air to insulate exit nozzles from peak combustion temperatures, to use variable area engine inlets and exits, to design super pumping systems for fuel, etc.

Potential of the ramjet

Some idea of the complex simplicity of the engine can be seen in engine compression. A conventional single-spool jet may attain a compression ratio of as high as 8 or possibly 10 to 1. Twin-spool engines may boost this to 12-1 while providing other advantages. But the ramjet engine experiences compression ratios ranging from 6-40 to 1 in the course of a routine flight.

It is the ramjet which shows the greatest potential in radical development from the standpoint of fuels. There have been many proposals for radical fuels of much greater energy. But in the conventional turbine engine existing limitations on turbine temperatures rule against practical use of such fuels.

There have been major developments in the field of solid fuels for turbine and ramjet engines. Leading the way is the so-called "slurry," a colloidal solution of solid fuels in regular JP4 chemical fuel. Solid fuels, such as boron, manganese, magnesium, etc., have long attracted the eyes of propulsion engineers. Their high heat values, many times that of chemical fuels, was attractive, but practical methods of application seemed remote.

Today these solid fuels, ground to dust-like fineness, have been successfully dissolved in regular jet fuels. The fuel simply acts as a transfer agent permitting the mixture to be pumped, metered, and generally controlled. The result is fantastic heat levels and equally fantastic engine power.

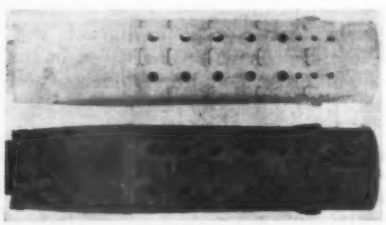
But this is yet in its infancy. The "solid" fuel must be kept in solution. Pumps and valves must be developed to handle the heavy viscosity mixture. Above all, there is the sand-blast effect of these highly abrasive mixtures throughout the engine. In a few minutes' time bearings can be ruined, pumps rendered useless, and combustion chamber walls disintegrated.

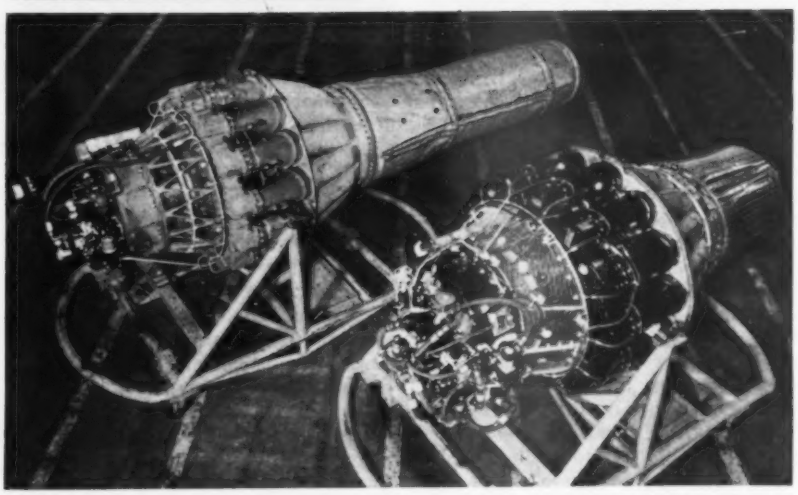
But real progress is being made and initially it is most likely to come about in the ramjet engine.

Rocket engine improvements

The rocket engine, both solid and liquid propellant types, is settling down to evolutionary processes of improvement. The industry has learned many lessons. Perhaps the most significant is that there are many compromises to be made in engine design to gain a good all-around engine.

The industry has settled down in its earlier tremendous drive to obtain (with little regard for allied problems) the hottest possible fuel. A few years ago there were virtually hundreds of rocket fuels under active consideration,





Critical metals content of the revamped Allison J33 used in the Martin Matador (rear engine shown here) was reduced 85% while engine cost was cut 30% by tailoring the engine to missile requirements. Changes included development of new turbine bucket material (upper left), an aluminum coating for combustion chambers (upper right), and a major reduction in engine accessories.

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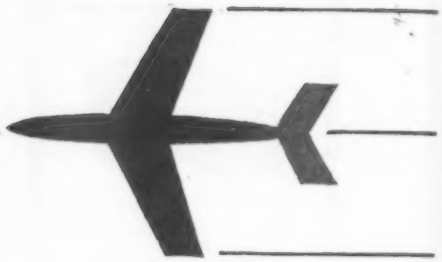

- **less weight** In a Saginaw Ball Bearing Screw every ball carries its share of the load. No balls "go along for the ride", simply as spacers. Thus, far fewer balls are required and therefore a substantially shorter, smaller and lighter, nut is necessary to contain the balls for a given load.

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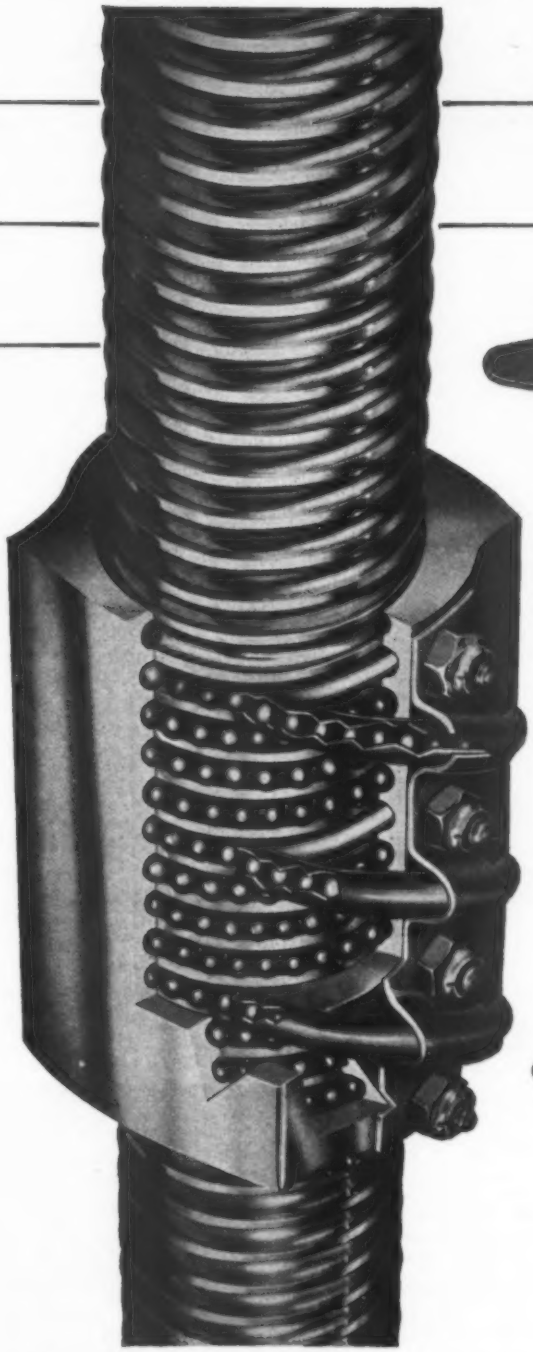

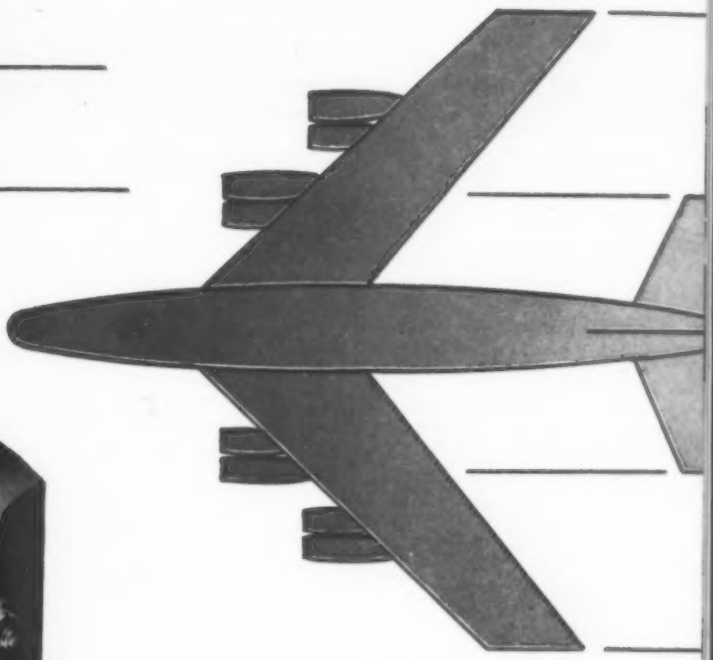

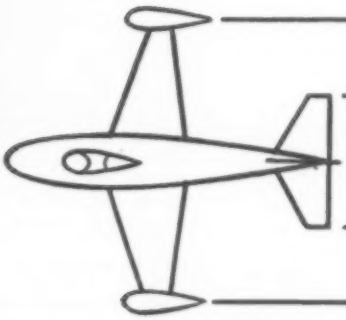

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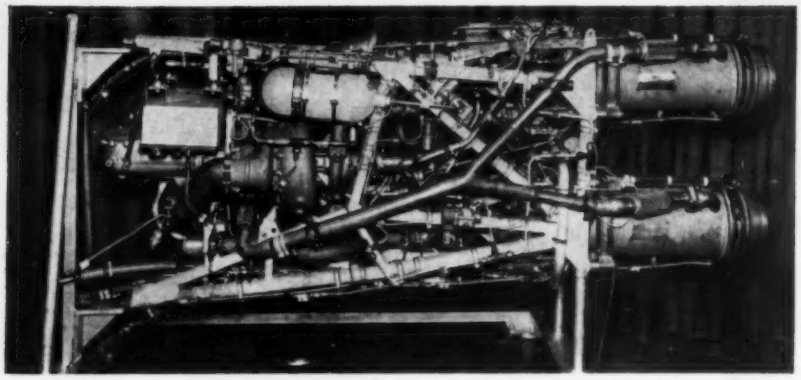


Security veils virtually all liquid propellant engines of current design. This Aerojet YLR-45AJ-1 engine, used for assisted-take-off of the Boeing B-47, provides some index to the size and layout of this type engine.

MISSILE TECHNOLOGY

and much laboratory and development time was spent in trying to match engines to their stringent, narrow-band requirements.

The race for the fuel with the highest specific impulse has been slowed. Designers have found that a well-balanced fuel may sacrifice 50-100 seconds to assure better combustion stability, keep temperatures down low enough to reduce regenerative cooling requirements, or ease the logistics problem of fuel handling.

In the U. S. Navy, for instance, most of the current liquid rocket engines use: (1) a hydrocarbon fuel and liquid oxygen oxidizer; (2) red fuming nitric acid/hydrocarbon fuel; or (3) liquid oxygen/alcohol.

There are, of course, exceptions for specialized purposes—squibs for starting non-hypergolic mixtures, driving turbopumps, etc. The acid/hydrocarbon is well received because it has a good specific impulse, yet is easy to handle.

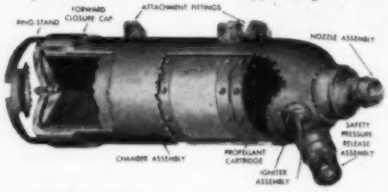
Rocket fuel problems

Liquid oxygen, which has a boiling point of —297 degrees F, has lost some ground as an oxidizer because of logistics and handling problems. Shipping liquid oxygen from manufacturing plants in this country to overseas bases, for instance, results in loss of about 2/3 of the initial shipment. There are also many transfer points en route and at each of them maintenance of temperature presents a real problem. Spillage can also prove very damaging, particularly on shipboard.

Another major lesson has been the matter of additives. The services have found practical additives that can be used to lower the freezing point of fuels, to minimize the effects of high temperatures and long storage on propellants, to make non-hypergolic (fuels that do not ignite on contact with the oxidizer) have spontaneous combustion on contact, etc.

This has been a major contribution because many fuel and oxidizer combinations were previously restricted in use by relatively minor problems. The problems also vary from service to service. The Army, for instance, shifted fuel combinations for the Nike surface-to-air missile because it wanted a hypergolic fuel. Previously it was necessary to use a slug of aniline in the feed lines to assure ignition when using WFNA and JP4.

Below are the designations and characteristics of some of Aerojet's unclassified military rocket units as well as a cutaway drawing which presents the general make-up of this type engine.



MODEL 15KS
Duration—15 seconds
Thrust—1000 pounds

Another one designed for carrier assist take-off, used for the 12-unit installation on the Douglas A3D, is:

MODEL 5KS
Duration—5 seconds
Thrust—4500 pounds

Another Aerojet rocket engine is:

MODEL YLR-45AJ-1
This is a liquid rocket engine with thrust and duration both classified.

In some cases, particularly for shipboard applications, the Navy tends to use non-hypergolic fuels. This gives them a safety factor in that any incident which might bring the fuel and oxidizer in contact accidentally will not set off the supply. In such cases a powder squib of a few seconds burning duration may be used in the same manner as a fuse is inserted to arm a weapon.

Handling problems have been no small factor in determining the direction of certain fuel and oxidizer choices. White fuming nitric acid has been largely displaced by red fuming nitric acid because of instability problems with the WFNA. Also, RFNA became more acceptable because methods, still classified, were developed for handling it.

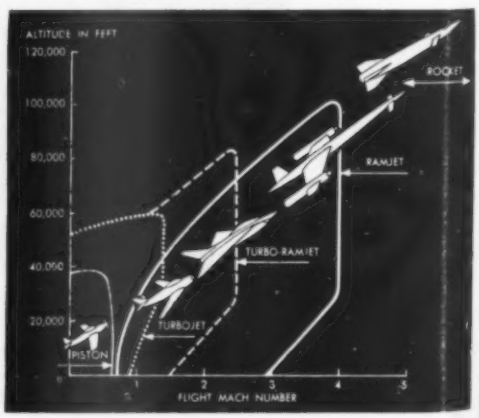
Another area of rapid improvement has been the materials situation. Improved systems of regenerative cooling have been one channel of improvement. Again, security veils the true nature of these developments. Rocket engine manufacturers have been quite successful in adopting graphite liners for the combustion chambers as well as ceramic coatings to permit higher temperatures.

These are not without problems, however. Graphite is subject to abrasive combustion products which can distort the shape of the exhaust nozzle and change a rocket's characteristics. Ceramic linings sometimes break up as a result of thermal shock, vibration, and other missile operating loads.

The trend in the USAF is, of course, to larger and larger rocket engines. It has been reported by top U. S. engineers that Russia has a liquid rocket engine of almost 250,000 pounds thrust. It is unlikely that the U. S. has such a high-powered engine, even in early development. This may be a basic difference in approach since there is evidence the U. S. industry is working on missile projects which could use a number of smaller units.

The solid rocket, exemplified by Aerojet-General's assisted take-off units, is marked by its relatively trouble-free status. There is a very active development program in this field, the direction of which is not clear. This program has brought new names to the front including such petroleum companies as Phillips and Standard Oil. Also prominent in new developments is Allegheny Bal-

PICKING THE RIGHT ENGINE



This is a Lear engineer designing a new autopilot

JOHN HARPER, B.S.E. (University of Michigan), is one of *ten* Lear engineers qualified and actively flying as jet pilots. But please note that these ten engineers are engaged *primarily* in the design, development, and perfection of automatic flight control systems, using their jet piloting skills only as an *engineering* tool.

At Lear, first-hand *in-flight* analysis is an integral part of development. As a result of this program, continuously checking theory against performance, Lear is exceptionally equipped to offer the most advanced solutions to the challenging and ever-changing problems of automatic flight stabilization.

LEAR

MISSILE TECHNOLOGY—PART 2

THE CHALLENGE TO ELECTRONICS

***"The electronic reliability problem is alarmingly serious, not only for missiles but all military electronics. Cost of maintaining equipment during its life period is found to be 10 or more times the initial cost. There are serious questions as to availability of personnel and facilities adequate in quantity and quality to provide necessary maintenance. Even more serious is the likelihood of sudden loss at a critical time in battle."*—McDONNELL AIRCRAFT CORP.**

VIRTUALLY the whole story of guided missile technology outside the realm of propulsion systems is inextricably one of electronics—electronics for guidance, stabilization, and flight control, for engine control, system programing, flight simulation, and range testing.

In fact, its penetration into the missile picture today has been so far-reaching, the success or failure of these new weapons of defense now hinges on the ability of the electronics industry to meet a challenge which far exceeds any it has faced before.

The challenge takes many different shapes. In guidance systems, where the failure of a single vacuum tube or sensitive relay can spell the complete loss of a $250,000 missile, component reliability demands become fantastic in comparison with those of piloted aircraft. A whole new set of numbers for shock loads, vibration, and heat, brought on by the very nature of missile propulsion and speeds, rule out any outright adoption of aircraft electronics hardware.

The challenge is still to be met. In today's missile it has only been compromised by make-shift adaptation of available equipment to satisfy the immediate defense needs.

Major problem areas remain to be overcome by further research and eventual development of equipment of new design to fit better the habitat of the missile. Among these areas are:

• **High Shock Loads**—A good percentage of electronic failures happen during the initial stage of firing, before the missile has a chance to be guided to a target but too late to call off the "shoot", repair the trouble, and start over. Accelerations of 50g are not uncommon with rocket boosters used on most ground-launched missiles. They play havoc with electron tubes and balanced relays originally designed for less stringent duty.

• **Vibration**—Missile propulsion systems, whether they be jet engine or rocket, are noisy. And noise means vibration. With frequencies covering the spectrum from one to 10,000 cycles, shock-mounting is out of the question, and even electronic components surviving the initial shock of firing often fail completely or malfunction in flight. One is as serious as the other—both can mean the loss of a missile.

• **High Temperatures**—Basic missile design accepts only the most compact of miniature and sub-miniature electronics packaging, and this, compounded with aerodynamic heating produced by high speeds, is far from conducive to good equipment performance. Despite the inherently short flight-time of missiles, new methods of heat dissipation have come into demand.

Silicon transistors, big hope for better missile reliability, are being produced by Texas Instruments, Inc.

Many of the problems growing out of these extremes of missile environment remain to be solved, but much progress is already on the record. The Navy Bureau of Aeronautics and Bureau of Ordnance, the Army Ordnance Corps, and the U. S. Air Force, the four agencies in the tactical and strategic missile picture, have adopted some quick-fixes to meet the immediate need while underwriting broad programs of research to permanently solve the problems for the future.

Principal areas of activity:

• **Electron Tubes**—First approach has been to weed out from the lengthy list of about 200 acceptable military tubes a highly restricted group showing the best promise of performance in missiles. BuAer and BuOrd have jointly adopted a list of 30-odd tubes for missiles which are subjected during manufacture to more stringent quality control, to microscopic and x-ray inspection, and to shake-tests, and are finally pre-aged or "burned" for about 48 hours.

The USAF, while not subscribing to the Navy's list of missile tubes, has its own similar restrictions on tubes for missile use.

• **Magnetic Amplifiers**—Wherever possible, magnetic amplifier circuitry is being designed into missile components to entirely dispense with the vacuum tube, not altogether successfully, however. In one Navy trial with a missile autopilot designed with magnetic amplifiers, the final unit was judged too costly, required too many solder joints, and was marginal in response performance.

• **Transistors**—Newest of the electronic cures for vacuum tube unreliability, and probably the biggest hope to lick missile problems is the transistor, particularly the silicon types for high temperature installations. But the problems here are twofold, one of production availability and another of cost, both tending to make their wide-scale use several years away.

To date, only one manufacturer, Texas Instruments, Inc., has announced production availability of silicon transistors and these are priced at about $30 a copy compared with an average $4 to $5 for vacuum tubes. But even assuming that single-manufacturer output is only a short-term probability, transistors call for new circuitry which cannot be developed and introduced overnight. Once the difficult problems of silicon processing are licked, real mass production will still only come when component producers have designed, built, and tested transistorized hardware and it has been evaluated in missiles.

• **New Tubes**—One other approach currently being viewed by BuAer for missiles is adoption of such new electron tube designs as the "stacked" tube developed for the Navy Bureau of Ships by Sylvania Electric Products Inc. By nature of its design, the Sylvania tube is inherently well suited for operation under conditions of extreme shock and vibration, making it a natural for guided missile use.

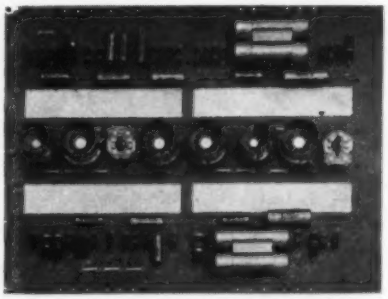
Design of the "stacked" tube dispenses with the conventional glass envelope and in its place uses a ceramic cap. Internal tube parts are built up on two small pins with the plate, grid, and cathode separated in the stack by ceramic spacers. An advantage of this type of construction is the adaptability of the tube to mechanized production, a factor that may very well bring it into wide-scale use earlier than transistors and at lower cost. One other big advantage is its direct interchangeability with present tubes in today's missile circuitry, with little or no redesign, making it a candidate for retrofit on current missile models to improve reliability.

Along these lines Sylvania has already designed tubes of the single- and double-triode types and is now developing diodes and pentodes. Production availability is still two to three years away, however.

Another similar development is the ceramic tube design being engineered for the USAF by Eitel McCullough, Inc., of San Bruno, Calif., which is cylindrical in shape and uses ceramic spacers between the tube components with the end caps of the cylinder coated to form the tube plates.

• **Workmanship**—About on a par with electronic design shortcoming is the impact of poor workmanship on missile reliability. As a quick remedy to relieve the situation, quality control procedures have been tightened up and test procedures made more rigid. Prime missile manufacturers, such as Boeing Airplane Co., producer of the Bomarc surface-to-air missile, have adopted such practices as testing all components on shake tables at loads up to 10g and at frequencies from zero to 500 cycles.

Rugged performance of Sylvania's new "stacked tube" shown here makes it a natural for missiles, but mass production is still 2-3 years away.



Conventional components are used in mechanized electronics approach developed for USAF by Stanford Research Institute.

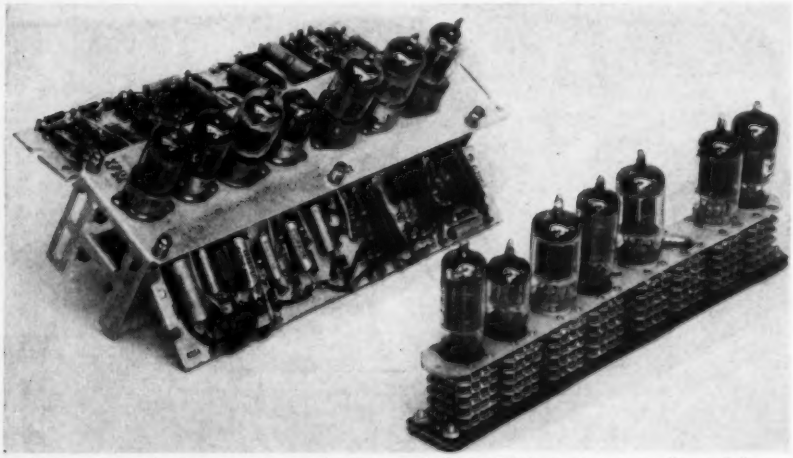
As Boeing's F. D. Reynolds describes some of the results of this testing on poorly designed equipment, "wire leads fly off, tubes jump out of their sockets, motors slow down, contacts chatter, brackets break, nuts and screws unscrew and drop off, and wires short together adding fireworks."

One of the biggest headaches experienced by BuAer in missile electronics workmanship has been with cold solder joints coming apart under vibration. The Navy considers this type of defect most elusive of detection, and is now looking to automatically produced electronic equipment such as its own "Tinkertoy" approach as the only permanent answer.

Reason is that in almost every type of automatic or semi-automatic production scheme so far unveiled, some form of dip-soldering under closely controlled conditions is employed. This feature alone, without considering the added benefits of more rugged overall construction through the use of etched or printed circuitry, would go a long way toward solving the workmanship problem, Navy technicians feel.

In fact, the feeling in BuAer on the importance of early changeover to automatic electronics production is so strong, it is now included as recommended practice on all production contracts let for new electronic components. Just how long this will remain merely a "recommendation" and not a basic part of BuAer's equipment specifications now appears to depend on industry reaction and extent of cooperation with BuAer.

The big obstacle to any wide-scale adoption of any one of the concepts of electronic automation, whether it be for missile or other military electronics equipment, now appears to be the wide number of schemes available and the inability of industry to adopt one for the Navy, another for the USAF, and something else for the Army. Although the Tinkertoy process, with its modular construction and use of printed circuits and tape resistors, is generally accepted as the most advanced, there are still the Air Force-sponsored method developed by Stanford Research Institute, Minimech approach of Melpar, Inc., for Bu-



Most advanced of automatic production methods is "Tinkertoy" process favored by Navy BuAer to improve missile electronics workmanship.

Ships, and more recently the Army Ordnance Corps' Frankford Arsenal development, all using conventional electronic components.

With the advantages of mechanized electronics production so obvious for better missile reliability and so necessary to meet production demands in event of a national emergency, some top-level Defense Department action appears wanting, if one or more of the processes are to get under way. Without such a move, the best that can be hoped for is some spotty appearances of each, with industry in general continuing to bide its time until some definite trends begin to show.

• **Reliability Research**—Despite the pressures of maintaining a broad missile development program without answers to the problems of electronic unreliability, research programs to find the answer continue down a variety of paths. In one approach, Army Ordnance has contracted with Wyle Laboratories of El Segundo, Calif. to examine all missile component test methods in use today and set up test-to-failure principles for future application. Where components lack qualification test methods, they will be set up.

Navy Bureau of Ordnance has tackled the vacuum tube reliability phase using the services of Aeronautical Radio, Inc. in much the same manner as in past military tube surveillance projects. Arinc is now accumulating failure data on tube rejects from manufacturers of six current BuOrd missiles and in 21 months of observation some 22,000 tubes have been returned as defective. Since it is virtually impossible to obtain accurate data on failures experienced in actual missile flight, these defective units represent only those detected during hours of testing from the time a tube is first received by a missile producer on through to the final checkout before missile firing.

One of the more promising research efforts, that being conducted for the USAF Wright Air Development Center by Armour Research Foundation, really gets to the core of the missile vibration problem. The ARF study is directed at the effects of high intensity noise such as produced by jet and rocket engines on vacuum tubes and sensitive relays.

Preliminary results of the testing at ARF has already pointed to the need for further investigation of the performance of airborne electronics components in the range above today's standard vibration test frequencies. Experiments with 6000 series ruggedized military tubes (subjected to noise levels of 140 decibels comparable to those in jet aircraft electronic equipment racks) revealed that two of three tested had spurious noise output that exceeded JAN specifications.

Similar tests at Armour with balanced, null-seeking relays of the type widely used in missiles have revealed that 110 db noise levels are sufficient to disturb relay operation and, at certain frequencies, a level of 130 db caused closed relay contacts to open.

What kind of missile electronics reliability will all this current activity bring? Although security restrictions and lack of positive data cloud any accurate measurement of performance today, some statisticians place electron tube failures as the cause of 86% of missile electronics failures, and total missile mishaps to about 60% of all fired. Aim of the Aeronautical Radio program is to bring failures due to electron tubes down to 2% of firings. In some missiles this could call for a phenomenal reliability, better than 99% in individual tubes.

By today's standards of performance, the electronics industry has a long way to go to approach such a goal.

• • •

MISSILE TECHNOLOGY—PART 3

STRUCTURES

TODAY'S MISSILES are of relatively conventional structural design. Tomorrow's missiles will have to be different. The changing demands are dictated by two factors: heat and production costs.

Heat is a problem primarily because of aerodynamic heating, the heat imparted to the entire missile surface by high rates of air flow.

Production costs have not been a problem because there has been virtually no high volume missile production. The Western Electric/Douglas Nike, currently the standard missile for continental U. S. defense, is probably the nearest thing to volume production, while the Martin Matador and Chance Vought Regulus are getting under way.

Many engineers look on the problems of the so-called "thermal barrier" as unique. The "sonic barrier," they say, was a transient thing resulting from research shortcomings. The industry simply did not understand the aerodynamic changes which took place when aircraft speeds brought planes through the speed of sound. When the problem was understood, solutions were apparent.

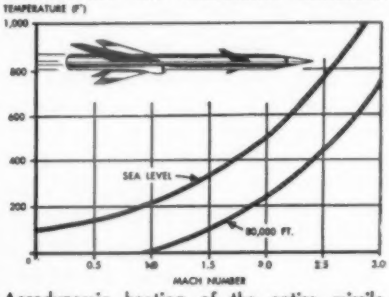
Not so with the "thermal barrier," they say High skin temperatures are inherent in high-speed flight, increasingly critical at high Mach numbers. The situation gets worse, not better.

Improved materials are one avenue of approach to structural integrity at high supersonic speeds. The industry's experience with piloted aircraft has provided a considerable backlog of aerodynamic heating data in the Mach 1 to Mach 2 speed range—from 650 to 1300 miles per hour. Beyond these speeds, in the area where many of today's missiles are operating, the missile is on its own.

At Mach 2, aerodynamic heating (see graph) brings skin temperature to 200 degrees F. This is virtually 200 degrees higher than the Mach 1 condition. By the time the missile reaches Mach 2.5 (about 1900 miles per hour), skin temperature has increased to 450 degrees F and at Mach 3 to 750 degrees.

To visualize the structural problem this creates one must look at the materials now used or contemplated for airframe construction (see graph). One of the more common airframe metals is 75ST. Its specific strength (strength/density in ksi/lb./cu. in.) runs 800 at temperatures of approximately 100 degrees F, the Mach 1.5 condition at 80,000 feet altitude. Yet at 200 degrees, characteristic of Mach 2 speeds at this altitude, its strength has dropped to about 675, and at Mach 2.5 is down to about 125.

BATTLING THE THERMAL BARRIER



Aerodynamic heating of the entire missile remains one of the most aggravated problems faced at high Mach numbers. This graph, based on a similar presentation by Douglas Aircraft Co., illustrates how temperatures soar after flight speeds pass the Mach 1 level.

The rapid rise of titanium's fortunes is easily justified by its relative position on this Lockheed graph. While its low temperature strength is little better than 75ST, it will maintain 600 ksi/lb./cu. in. specific strength at temperatures as high as 700 degrees, and maintains better than 400 to 900 degrees F. The relationship of these temperatures to flight Mach numbers is shown on the accompanying graph.

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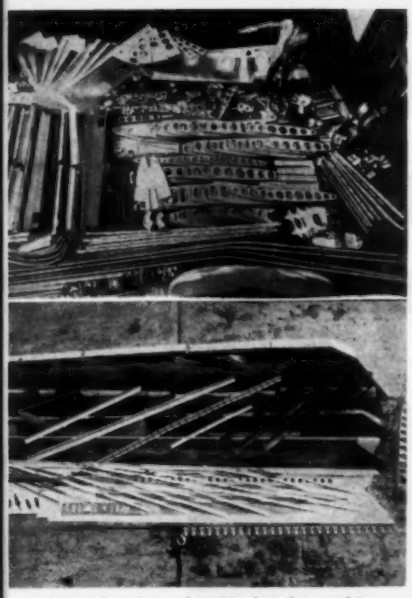


Martin's claim for Marbond, combination honeycomb and metal bonded structure, is verified in these two photos. At top is a stabilizer showing the hundreds of parts in a conventional structure; below the wing of the Martin B-61 (about the same size as the stabilizer) showing its simplicity.

the glass laminates shown on the graph, may find applications in certain missile types because of their relatively good temperature characteristics combined with weight, cost, ease of production, availability, etc.

At first glance it might appear that cooling, through use of refrigeration equipment in the aircraft, might be possible. USAF studies, made at New York University's College of Engineering, highlight this problem. At Mach 3 (about 2100 miles per hour) it would take about a three-ton refrigeration capacity per square foot of skin surface to drop the temperature to 100 degrees F. (a standard room air conditioner has one-ton capacity). A plane flying at five times the speed of sound, under one set of circumstances, would have the same cooling requirement as a large building in the tropics.

LaBombard's views

It appears that answers will have to be found in structural innovations. This can be done but with extreme weight penalties. The relationship of this problem to the one of "breaking through the sound barrier" has been interestingly expressed by Douglas Aircraft Co.'s Emerson H. LaBombard:

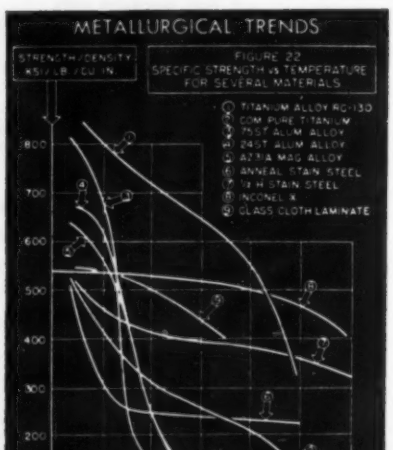
"At one time the drag forces on an airplane flying at the speed of sound were determined and it was found that no known powerplant could deliver sufficient thrust to overcome these forces. Not long after the term (sonic barrier) was popularized aircraft designers developed airplanes and airfoils with less drag than before, powerplant designers created engines with more thrust than before and the 'sonic barrier' was shown to be non-existent.

"The 'thermal barrier' concept is similar. Materials lose strength at the high-speed temperatures, so high-speed airplanes must be heavy. No known powerplant can push this heavy weight through the air, therefore high speeds are made unavailable to us by a 'temperature barrier.' Again, I am sure, the same thing will happen. The metallurgists will develop materials with more hot strength, the powerplant designers will provide more thrust, and the 'thermal barrier' will be shown to be non-existent."

How much weight penalty?

LaBombard also has some ideas on how much the weight penalty for high temperature might be: ". . . by selecting the best material strength-weight wise corresponding to the particular operating temperature, we can expect our structure to weight 10% to 100% more than the low temperature structure would weigh. It is interesting to note that, because the change in strength with temperature is not linear, the best material may be aluminum, steel or titanium, depending on the particular operating temperature involved."

The potential for cutting missile production costs by simplified production methods is more clear cut. Many structural design parameters are based on long life expectancy—long life while exposed to constant vibration at varying loads and frequencies. Designs incorporate generous safety factors, etc. Gradually new sets of structural standards are bound to develop.



Real nature of the high temperature problem is highlighted in this Lockheed chart showing the drastic reduction in metal strength at elevated temperatures.

Meanwhile structural methods which had previously been restricted to laboratory test or secondary structures are being adopted. One current production missile is largely constructed of reinforced phenolic resins. This work is reportedly being done by a firm which 12 to 18 months ago started production of large fuselage sections under sub-contract to one of the larger airframe companies. While fuselage sections of this type carry only secondary loads, in missiles the same approach is being used for the load-carrying members.

There are other approaches. Perhaps the integral engine design of the Bendix Talos is another area where appreciable production economies can be realized if related problems can be ironed out. Since this is a ramjet engine it is more susceptible to an approach of this type than are most missiles.

Martin's approach to Matador production (see photos) offers some valuable guides to both cost and producibility. More than 80% of the Martin B-61's wing and tail plus some internal structure utilizes Marbond, a structure made up of honeycomb-like material of aluminum foil forming the load-carrying base for conventional aircraft skin. The skin is bonded to the honeycomb.

Honeycomb wings

The results: Cost of the honeycomb wing is about one-third that of wings built by conventional methods. Production time is about one-fourth that of earlier methods, and manpower requirements are greatly reduced. Typical reason for the cost reduction: Joining the two halves of the wing to their respective center fittings by means of Marbond eliminates the drilling, tapping, and insertion of 425 bolts.

The Matador, like the Chance Vought Regulus I, is of rather conventional aircraft configuration. Both planes incorporate much standard production practice. The wingless nature of many missiles does not permit widespread application of Martin's technique in lift members, but it could be used, apparently, with good effect in flight control surfaces and perhaps in portions of the fuselage.

Little is available on structural details of most of this country's missiles. What is available—on the Matador, Regulus, and Ryan Firebee—tends to show considerable effort toward structures which can be readily disassembled (see photos) for shipping, storage, and maintenance. If evident trends in use of recoverable fighter-type missiles (for carriage of air-to-air missiles) continues, such characteristics might eventually lend a hand in missile overhaul.

• • •

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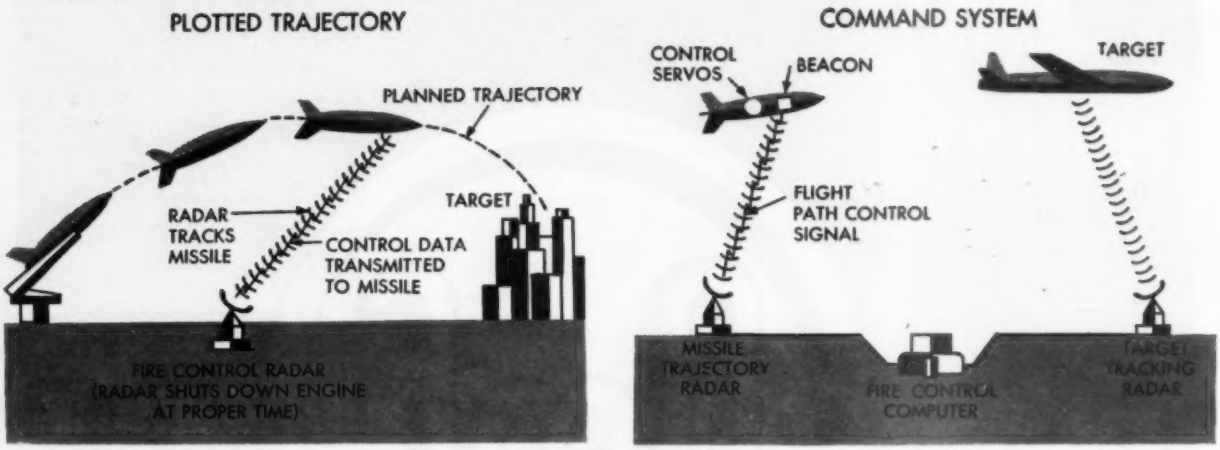


Two common approaches to missile guidance.

THERE ARE as many systems of missile guidance as there are missiles, perhaps more. Yet one of the biggest unsolved aspects of missile warfare is the development of an effective, reliable, long-range guidance system.

What characterizes such a system? Accuracy, dependability, and range are probably the three most critical demands. Beyond this it must be reasonably free from jamming, require little if any ground equipment and preferably be of a type that produces little or no signal which the enemy might use in tracking it down en route.

Each of the known systems of navigation will fill some of these requirements. Virtually all of them have apparent shortcomings. The nearest thing to a perfect navigation system for missiles is probably one of the many inertial guidance system proposals. Some of these have been reduced to prototype hardware and in cross-country flights of military aircraft have tended to verify the claims of their backers.

The seriousness of any guidance shortcoming is directly related to the mission of the missile. There are, of course, unguided missiles. These are primarily surface-to-surface missiles (such as Douglas's Honest John) which are short range and which follow a ballistics trajectory. Since they benefit from centuries of ballistics experience, missiles of this type are reasonably reliable.

The longer the mission, the more difficult the problem. The short range problems, however, are complicated by the speed of target movement. The long-range guidance problem, typified by the 5000-mile New York/Moscow leg, is difficult because a fractional degree error over the route length would result in a complete miss.

There are many combinations of circumstances where a guidance system with known shortcomings for ordinary missions will still be the best for the job at hand. Thus a guidance system based on detection of infra-red rays (heat) has many limitations. It is very short range, about 10 miles at night and even less in daylight. Artificial "targets" (for instance, infra-red searchlights) can throw the missile off course.

But heat detectors may prove extremely valuable for specialized conditions, for instance, intercepting a supersonic missile of predominately plastic construction fired on a ballistics trajectory. If developments permit future infra-red systems to home on heat caused by the skin friction of supersonic missiles, or to gain sufficient signal strength from a head-on approach of another missile or aircraft (from the radiating exhaust heat), heat detectors could prove of unique value.

These have been a few generalized considerations. Here are some of the systems in use or under active consideration for specific tasks:

• **Active Homing:** Missiles using this system contain a complete radar installation. Range of these radars is not great enough to handle the missile throughout its flight so it is tracked with more powerful ground or airborne radar and steered along the desired course. When the missile gets within the useful target range of its self-contained radar, missile control is turned over to this unit which homes on the target.

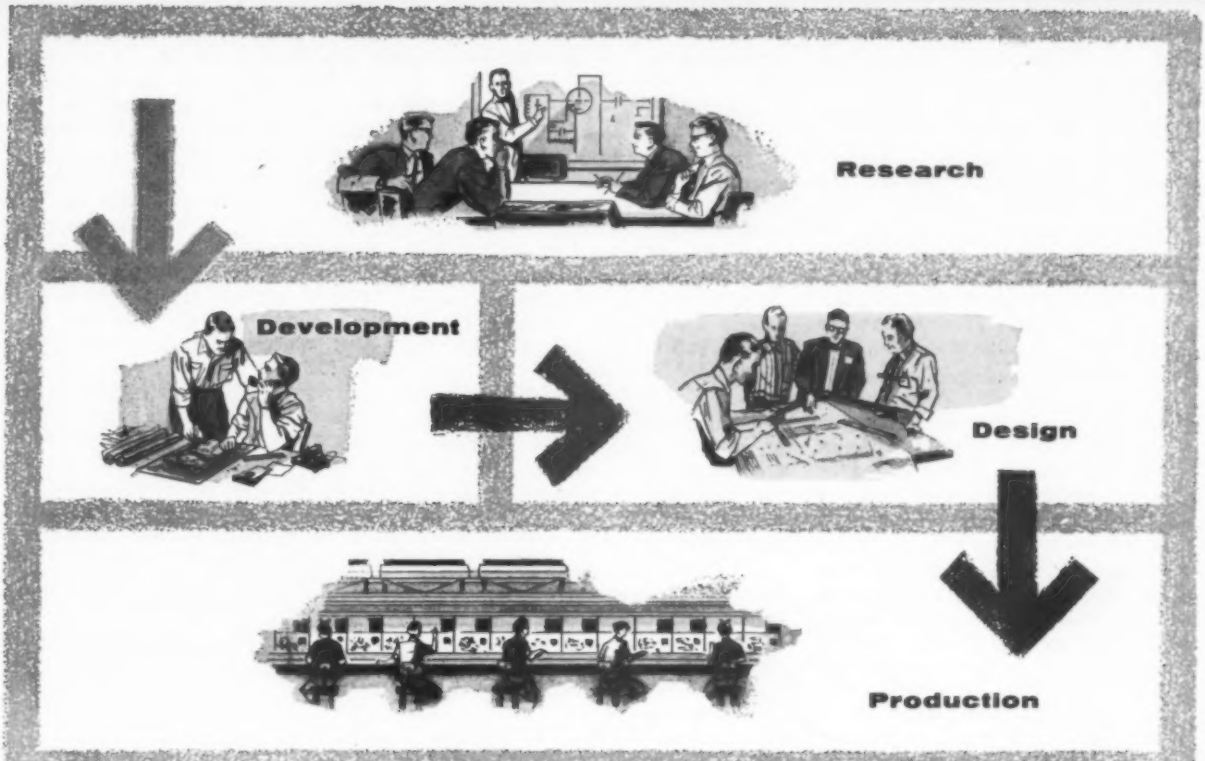
In such systems the radar echo reflected from the target is received in the missile, measured, and used to generate control signals for the gyros and servo mechanisms which control the missile's flight path. Radar systems are reasonably easy to jam. Present day bombers carry chaff dispensers which drop tin foil into the air and completely disrupt radar detection. Presumably missiles may be built to measure radar impulses and automatically dispense jamming chaff, although some computing systems can identify and ignore chaff.

• **Passive Homing:** There are a number of such systems including those responding to light, heat, and electromagnetic radiations. As a group they are characterized by the need for information which is generated by the target. Anything which the enemy can do to minimize or eliminate the generated signal, or to set up false signals, foils the system.

• **Heat seekers,** such as used by the Navy's Eastman Kodak Dove, are getting the most attention in this group. Heat forms part of the light spectrum. Devices which measure light can measure heat radiation, if they are sensitive enough. Instruments of this type are called bolometers. Since they respond to heat, they are less effective in sunlight or in the presence of multiple heat sources. However, by their nature, these guidance systems gain increased accuracy as they approach their targets.

It is apparent that heat seekers and electromagnetic systems would be effective in searching out radio transmitters, factories, power stations, etc., all of which produce strong signals of these types.

• **Command System:** One of the more precise ground-to-air guidance systems is the command system, such as used for the Western Electric Nike. Its operation is based on two fire control radars (radars which automatically



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track a single target). Once the long-range surveillance radars pick up the warning of enemy aircraft, one fire control radar is used to track the target. Another is used to track the missile.

When the missle is fired, the ground controllers can view its path with relation to the target on search or surveillance radar. Signals from the target-tracking and missile-tracking radars are sent to a fire control computer which constantly plots interception data and feeds it to the missile control system through the radar link.

Command system missiles may include a promixity fuse to detonate the warhead or may depend on a direct hit. In some such systems, but not in the Nike, initial alignment is provided by human controllers and the system is subject to human failings as well as to radio frequency jamming.

• **Beam Rider:** Used primarily for anti-aircraft applications (including the Bendix Talos), the beam rider system of guidance employs a target tracking radar to form a narrow beam between the missile launching site and the enemy target which has been picked up on search radar. The missile is launched in such a manner that it intercepts the coded radar beam. The target tracking radar automatically follows the target.

In the first few seconds of beam riding, a computer within the missile works out the speed and directional data necessary to redirect the missile with sufficient lead (similar to the human hunter's habit of firing ahead of a bird on the wing) to assure a collision course. This feature is not used when the system is designed to overtake the target.

• **Celestial:** Based on the oldest form of navigation, celestial guidance of the missile depends on successful development of some complex automatic tracking telescopes. It is almost in a class with inertial guidance and would be used primarily on long-range surface-to-surface or air-to-surface missiles.

In celestial guidance a computer in the missile is provided with star tracking data based on the known trajectory. Automatic tracking telescopes, using star angles and possibly star brightness for references, "shoot" two stars on a continuous basis. Data sensed by the telescopes is automatically compared with the predetermined course data in the missile's computer. Deviations generate error signals which are transformed into control system movements.

Although limited by the problems of overcast skys (and consequently altitude-sensitive), celestial systems are very promising for intercontinental missiles because they are immune to countermeasures.

• **Plotted Trajectory:** This system is used for surface-to-surface applications with a fire control radar tracking the missile from launching to the point of engine cut-off. A radar tracking beacon in the missile strengthens radar signals and receives course correction data from the fire control radar. In practice, a ground computer compares the missile trajectory with a predetermined correct flight path. Variations are converted to error signals which are received by the missile's radar beacon and bring about corrective action by the control surfaces.

Radar also controls the point at which the engine is shut down in order for the trajectory to bring the missile onto the target. It is not possible to use active control of the missile's directional devices in this stage of the flight (except through programing devices) because the missile is below the "line of sight" requirements of radar control.

• **Semi-active:** A target tracking radar is used to concentrate radar impulses on the target which has previously been detected on search radar. The missile homes on the reflected energy from the target.

• **Inertial:** Super sensitive accelerometers (generally one to measure left/right accelerations and another to measure fore and aft accelerations) form the core of these systems. Refined gyro systems, relatively free from precession and with corrective provisions, provide a fixed reference for the missile in space. All predetermined forces (take-off acceleration, changes in flight path throughout the trajectory, etc.) have been plotted and the results incorporated in a computer.

Any unscheduled force (winds, gusts, engine power variations, etc.) produce accelerometer reactions which are fed into the missile's controls as delicately proportioned error signals.

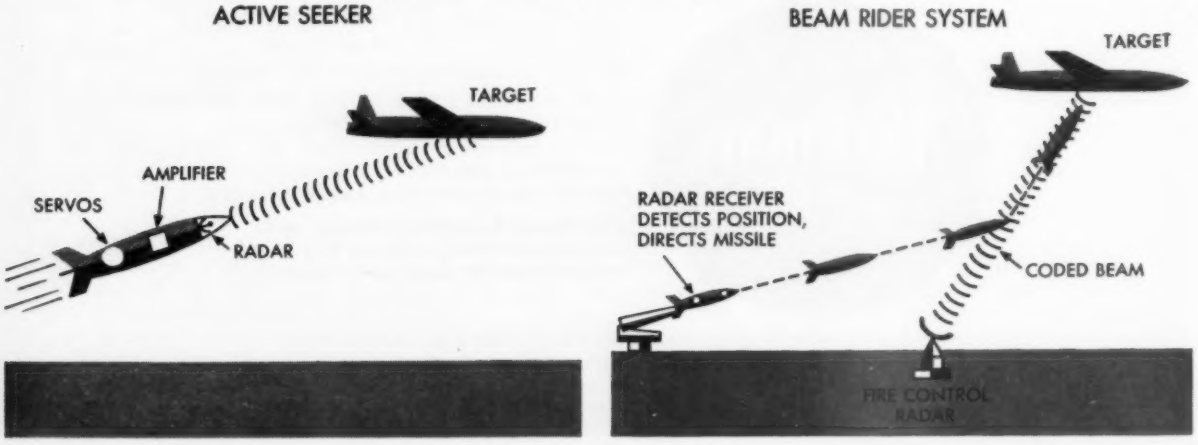
Inertial systems are in their infancy but show great promise because they cannot be jammed, although the missile might still be shot down.

• **Hyperbolic systems:** A very accurate long-range navigation (guidance) system for surface-to-surface or air-to-surface missiles, the hyperbolic approach requires at least two ground stations and is subject to countermeasures. It is also somewhat subject to weather phenomena.

Essentially, two ground stations transmit signals which overlap each other so as to form a grid over the route to the target. A receiver mounted in the missile measures the time delay between signals received from these stations and translates it into position data. This is possible because there is only one position on the grid in which the missile could be and still maintain that exact time relation to the ground stations.

Data obtained in this manner can be converted to corrective movement of the missile's control system. The most widely implemented hyperbolic navigation system is Loran, but Gee, Raydist, and Decca could be used in much the same way. • • •

Diagrams below illustrates two more guidance systems.



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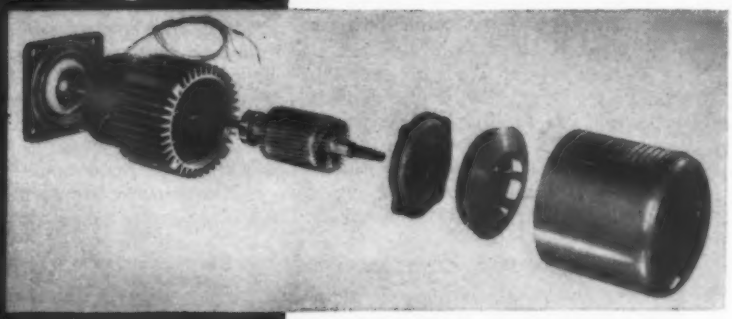

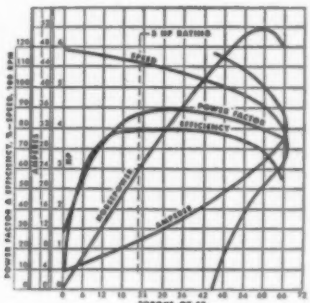

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2000 mile per hour British guided missile, an unnamed early model, shown as four pairs of boosters break away after they have accelerated the "bird" and burned out.

MISSILES OF THE NATO NATIONS

In Britain, after a late start, every major aircraft company is in the missile business; France feels that it is being ignored

THE INFLUENTIAL and generally well-informed London *Economist* commented as follows on June 19 last after British Supply Minister Duncan Sandys returned from his talks on Anglo-U.S. weapons co-operation with U.S. Defense Secretary Charles Wilson:

"Guided weapons were not seriously studied in this country (Great Britain) until three years after the American program had started, consequently the first generation of British guided weapons is not likely to be in service as soon as the American, but when they do begin to appear, in roughly two year's time, they should in some cases embody more advanced techniques."

"A great deal of unnecessary secrecy surrounds the amount of work on guided weapons that has been done in this country, at a cost of several millions of pounds for each design."

To gain an idea of the general trend of British development of missiles, it is essential first to appreciate the entirely different defense requirements of the U.K. and the U.S. The British Isles form a concentrated, widely industrialized target with no point more than 70 miles from a coastline, approachable on all sides, save the east, over large areas of water without the possibility of radar watch. Defensive weapons, therefore, have to be developed along three lines:

• **Air-to-air** missiles carried by large all-weather patrol fighters, such as the Gloster Javelin and daytime interceptors, like the Supermarine Swift and Hawker Hunter.

• **Ground-to-air** long-range peripheral (coastal defense) missiles.

• **Ground-to-air** short-range target defense missiles.

Such weapons are known to be under development and are at the stage of selective service trials.

Further concern about progress was aroused in the summer when it was announced that the British army was to receive WAC Corporals for trials and Honest Johns for its long-range artillery. This situation implies one of three possibilities: (1) Backward British missile development; (2) Neglect of ground-to-ground missiles only; or (3) A move toward Anglo-U.S. standardization.

In 1953, after a considerable inter-ministry and underground political struggle, control of guided missiles for air defense became solely an RAF commitment. This decision reversed one, made in late 1944, when the German V-1 flying bomb and V-2 rocket were declared to be long-range artillery, so placing the first onus for intelligence and countermeasures upon the army.

The principle argument for air control of ground-to air missiles is that they

English Electric's major missile development to date is shown here as it leaves the launcher.

Carrier Based Jets to have Radar Guided Missiles

NAVY'S AIR-TO-AIR SPARROW 1 IN PRODUCTION

THE STORY BEHIND THE STORY:

■ On May 12, newspapers from coast to coast carried headlines like the ones above, announcing the Navy's newest weapon of defense—Sparrow I—and the beginning of volume production for operational use in the fleets.

■ Ahead of these headlines were 7 years of intensive cooperative effort shared by the Navy's Bureau of Aeronautics and Sperry.

■ Originally designated project HOT SHOT, Sparrow began back in 1947 when the Bureau of Aeronautics assigned to Sperry the full responsibility of creating an entirely new air-to-air missile system. It had to be light and compact – so multiple units could be carried by fighter-type jets. It had to be deadly accurate – capable of outmaneuvering the swiftest bombers an enemy could produce. And it had to be practical—suitable for large-scale production.

■ The rocket-powered, radar-guided Sparrow I, coming off the production lines here and at the new Sperry Farragut plant in Bristol, Tennessee, meets these requirements—and more. It embodies the proved features of more than 100 different missiles designed, constructed and tested during a 7-year period – and the finest brains of an organization that has devoted more than 40 years creating and manufacturing automatic flight control and fire control systems.

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behave more as an aircraft than a shell and that the RAF better understands their handling in all its aspects. Also, in the organization of the Air Defense of Great Britain, that is fighters and artillery, overall control is exercised by the commander of the RAF's Fighter Command, to whom the Army C-in-C Anti-Aircraft Command is responsible.

Separately, the RAF will be responsible for operating, and its supporting ministries of Air and Supply for developing, air-to-air and air-to-ground guided weapons in conjunction with the associated weapon-locking and aiming radar, for integration into the defense system.

In parallel, the Royal Navy has been evolving its own special missiles for the defense of ships at sea and a test ship is in use in home waters. This particular missile, made by Armstrong Whitworth, is also being tested at the Woomera missile range in Australia.

Britain finances Woomera

No evidence, or mention, has yet been forthcoming about offensive missile developments such as the pilotless bomber or the air-to-ground guided bomb.

Because of lack of large barren spaces in the U.K., the main test area is at Woomera—where even long-range missiles can be fired. There have been various statements about the payment for this establishment and it has now been agreed that, although the building was done by Australia, the financial responsibility is Great Britain's. The original estimate for the cost of Woomera base was $112,000,000.

This figure is just about the only indication there is of the money being spent on weapon development, because in the U.K. there is little detailing of the defense budget. In particular, the Ministry of Supply gets a block development vote.

It is important, in this context, to realize that it is finance which, more than anything else, acts as a brake on European missile development. It is extremely difficult for politicians and their advisers to make the decision to allocate so many millions to the research and development of weapons of the future when the air force itself may lack jet bombers and be equipped with obsolete fighters. It is a guessing game of deciding how far to gamble upon there being no war until the new weapons are ready.

For example: The U.K. policy is, first, to re-equip its home defense squadrons with all-weather fighters and to arm them with target-seeking missiles; then to evolve the target and coastal defense ground-to-air missiles to supplement the fighter screen. Next stage is to equip the existing Canberra tactical and the shortly-to-be Valient, Vulcan, and Victor strategic bombers with air-to-ground guided bombs. Long-term planning is then to replace the bombers—in 10 or 20 years—with long-range pilotless missiles *after* the army's artillery has been supplemented by short-range missiles.

In Britain, every major aircraft company is in the missile business. In fact more engineers and scientists are employed on missile work than in the entire British airframe business. The following concerns are among those actively engaged in missile development work: **Armstrong-Whitworth** (ship-to-air); **Bristol** (ramjets); **de Havilland Propellers** (air-to-air); **English Electric** (ground-to-air rockets); **Fairey** (rockets); **Folland**; **Miles**; **M. L. Aviation** (target planes); **Royal Aircraft Establishment** (rockets); **Vickers-Armstrongs.** No details of the missile activities of these concerns may be mentioned.

The unstable and inflationary economy of France is naturally even more affected by the fantastic cost of guided missiles than is Britain's. On the other hand, the French have a genius for invention and an inveterate interest in novelty. Some work is being done on missiles but is almost entirely within the security wrap.

French Air Force Secretary Diomede Catroux recently indicated that a long-range ground-to-ground missile is being developed in France but it is not known which company is entrusted with this project. Concerns in the guided missile field in France include the following:

Societe Générale de Mécanique-Aviation-Traction (MATRA) which

France's SNCASE displayed this missile model at Paris.

has developed an air-to-air missile specified as an underwing load on all new fighters for the French Air Force. This, or the 1760-lb. air-to-ground missile, is carried in the ventral bay of the SNCASO Vautour all-weather fighter.

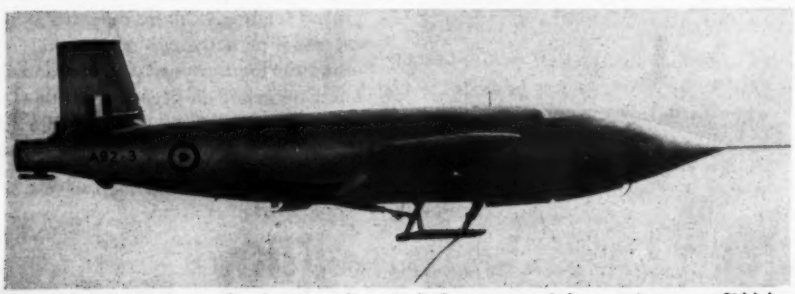
SNCA du Sud Est (SNCASE) has a missile division at Cannes which is believed to have developed a ground-to-ground missile in the Matador class powered either by ramjet or expendable turbojet.

Etudes et Constructions Aéronautiques (ECA), a gyro, instrument, and servo specialist which has made controlled targets and missiles.

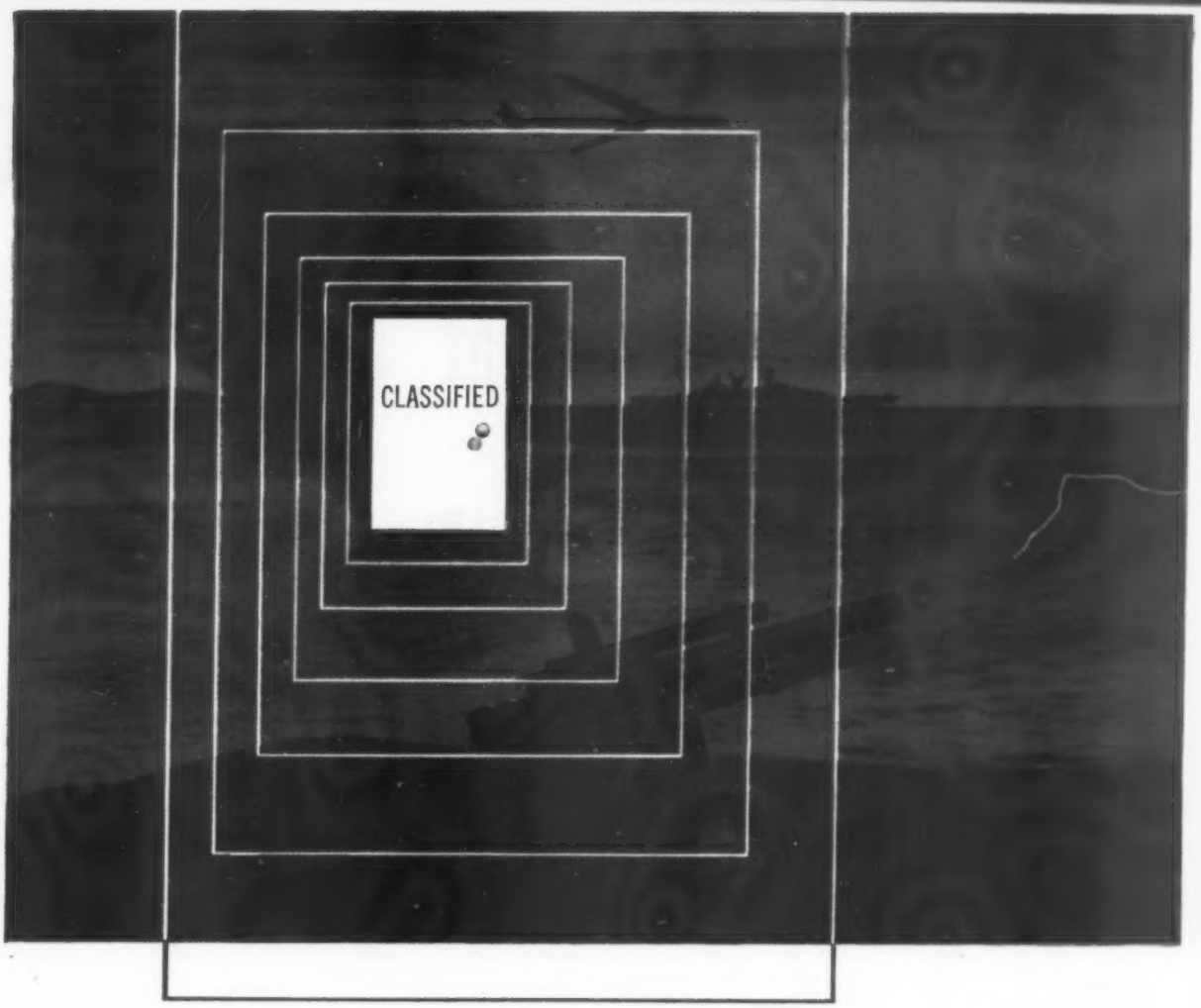
Société Francaise d'Etudes et de Constructions de Matériels Aéronautiques Spéciaux (SFECMAS), a nationalized concern formed out of the Arsenal de l'Aéronautique, which is specially charged with the development of missiles, radio, controls, and power units. SFECMAS has flight-tested a subsonic ramjet, the 1100-lb.-thrust S.600 and has developed the SS-10 wire-controlled anti-tank missile which has been ordered in some quantity for field tests by the U.S. Army. The latter is a small finned rocket, stabilized by a high-speed powder gyro and controlled from an optical sight by electrical impulses transmitted by wire to spoilers on the fin. Upon impact the sight is automatically reset for the next round. A development of the SS-10 for air-to-ground work is the missile around which the Potez 75 light attack monoplane was designed.

Many French engineers, incidentally, complain that they are not permitted to share the secrets of the British and American missile technicians. There is a strong feeling that France is distrusted, and resentment is felt not only at this but also because the results of French inventiveness are ignored.

In the rest of Europe generally, there is neither the money nor the industry for missile development. It is known, however, that Sweden's Saab Lansen all-weather fighter will be armed with air-to-air missiles. The Swiss Oerlikon company has made a ground-to-air beam rider specially suited to the defense of its small and mountainous country. Norway, surprisingly, is developing guided missiles for coastal defense and has set aside some $700,000 for development. • • •



Essentially a target aircraft, the Australian Jindivik is powered by an Armstrong-Siddeley Adder A5A-1 or, in production planes, by the Viper. Radio guidance. Length 22 feet.



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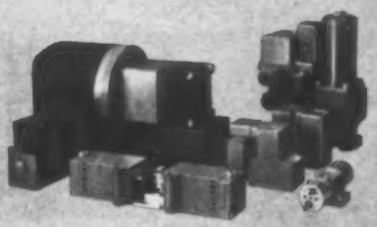

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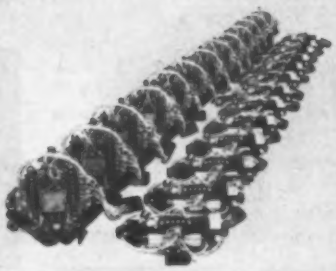

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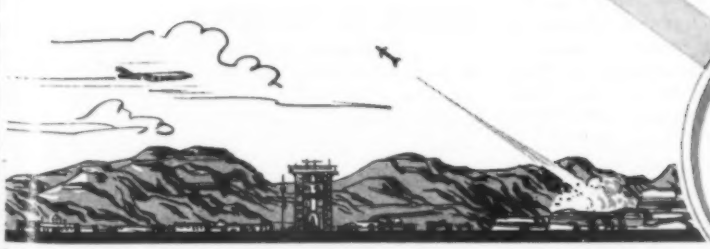

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MEN BEHIND THE MISSILES

Here are biographical sketches of a representative group of the top missile engineers in this fast-growing industry . . .

BROMBERG OF McDONNELL

Ben G. Bromberg, chief missile engineer, joined McDonnell Aircraft Corp. in 1947 after receiving his doctorate at MIT for work on development of gun and rocket fire control systems. In his present capacity he is responsible for design, development, and testing of missiles and rockets.

In his early career, after receiving his masters degree from New York University and winning the Sylvanus Reed Fellowship, he worked with Grumman Aircraft Corporation and then Curtiss Airplane Division. From 1939 until 1945 he was with Consolidated Vultee as a structures engineer, research engineer, and on up to chief technical engineer in charge of aerodynamics, flight test, and structures.

Bromberg

Hoffman

HOFFMAN OF NAA

Samuel K. Hoffman, as manager of the rocket engine facility, is in charge of all phases of rocket propulsion work, including the rocket engine field laboratory at Santa Susana. He joined the company in 1949 in the aerophysics department.

Since graduating from Penn State, he's been with Fairchild, Lycoming, and Allison. From 1930 to 1934 he was project engineer with Lycoming Division, rising to assistant chief engineer. In 1945, he returned to his Alma Mater as professor of aeronautical engineering until joining North America.

JEWETT OF BOEING

Robert H. Jewett, chief project enginer, pilotless aircraft, launched his first missile project in 1945 in the Gapa (ground to air pilotless aircraft) program at Boeing as preliminary design unit engineer. He directed the program to its successful conclusion and has been involved in pilotless aircraft ever since. He is currently directing the engineering of a complete weapon system program, of which the F-99 Bomarc is a part.

Prior to joining Boeing in 1937, he was with the War Department and The Glenn L. Martin Co. During his career at Boeing, he has been with the powerplant, aerodynamics, stress, and preliminary design units. He received his B.S. in aeronautical engineering from the University of Minnesota in 1931.

He is currently Boeing's representative on the Guided Missile Committee of the Aircraft Industries Association.

Jewett

Perry

PERRY OF CHANCE VOUGHT

Oliver Perry, Jr., chief of missile design was associated with the Regulus program as chief of field test and flight operations prior to his present assignment. He is responsible for a large portion of the analytical work on servomechanisms for the program.

Perry joined the company in 1941 as a mold loft employee. He took time out from 1943 through 1946 to serve in the Army Air Corps, where he earned his multi-engine pilot rating and lieutenant's commission. Before leaving the service he was a project engineer in the aircraft laboratory at Wright-Patterson AFB.

On his return to Chance Vought, he went into the pilotless aircraft section. He was transferred to California in 1950, where he served as assistant to the chief of missile design until assuming responsibility for testing and flight operations.

BALLHAUS OF NORTHROP

William F. Ballhaus, chief engineer, was chief of preliminary design at Convair-Ft. Worth before coming to work under Edgar Schmued at Northrop. Prior to that he had been with Douglas as project engineer on the A3D.

A Stanford graduate and a Cal-Tech Ph.D., Ballhaus was the recipient of the Switzer Research Fellowship and the Rosenberg Research Fellowship. He also was awarded the Eckart prize by The Institute of the Aeronautical Sciences.

Ballhaus

Melrose

MELROSE OF REPUBLIC

Robert G. Melrose has served as general manager of the Guided Missiles Division since its inception two-and-a-half years ago. A 19-year man with Republic, he has been in the engineering and manufacturing departments, rising to director of the technical liaison division.

He received his B.S.M.E. from Polytechnic Institute of Brooklyn in 1933, and the following year got his aeronautical engineering degree from New York University. He holds a commercial pilot's license and is a member of IAS, ARS, the American Ordnance Association, and Lambda Chi Alpha.

BATES OF RYAN

Curtis L. Bates, assistant director of engineering, first became associated with Ryan in early 1953. Prior to that time he had served as chief of mechanical design for Northrop for 11 years and had been associated with the development of the P-61, B-34, and B-49 flying wings, and the F-89. He also developed the launching sleds for the Navy Loon.

His 22 years in the industry included four years as director of aeronautical engineering and acting dean of the Lawrence Institute of Technology and two years as chief designer at Aero Industries. He received his aeronautical engineering degree at the University of Detroit and did advanced study at the University of Michigan.

IRVINE OF CONVAIR

C. R. (Jack) Irvine, in his capacity as assistant to the vice president of engineering, has the responsibility of coordinating the company's missile development activities in both the Pomona and the San Diego divisions. His early career predestined his Convair association—first as project engineer for Stinson Aircraft Co., then with Vultee Aircraft Co., both companies later merging with Consolidated.

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In San Diego he was chief engineer for missiles and fighter aircraft until appointed assistant division engineer in 1948. In 1951, he was appointed assistant division manager and chief engineer for Convair's guided missile division at Pomona, Calif. He received his aeronautical engineering degree from the University of Michigan.

Irvine

Smith

SMITH OF MARTIN

George E. Smith is the man behind the Matador in his capacity as manager of B-61 operations. He came to Martin in 1939 after earning his B.S. degree in Aeronautical Engineering from Georgia Tech. His first assignment was in structures.

He is recognized for his contributions to the B-26 Marauder while in the stress analysis and airframe design department. After the war, he became a structures engineer on transport planes. In 1950, he became assistant project engineer on the B-51 tactical bomber, later taking over on the Matador project.

WOOD OF BOEING

Lysle A. Wood's appointment in January 1953 to the newly created post of director of pilotless aircraft emphasized Boeing's growing interest in the pilotless aircraft program. He was switched over from chief engineer, which post he had held since 1948.

Wood came to Boeing 28 years ago after graduation from Montana State College. In his tenure, he has headed project groups responsible for the design of the Boeing 307 and the Model 314 flying-boat. In 1939 he was made commercial projects engineer, in 1942 executive engineer, and in 1943 assistant chief engineer.

Wood

Purdy

PURDY OF MARTIN

William G. Purdy, rocket project engineer, is credited with helping to create the ionosphere-penetrating rocket the Viking, of which 11 have been built. One holds the world's record of 158 miles for single-stage rockets.

Purdy joined Martin in 1941 directly from the University of Missouri. He was first assigned to the field of vibrations and flight test instruments. He was named project engineer in 1947 after the Navy awarded the company a contract to build and flight test the space-probing rockets.

He is currently the president of the Baltimore chapter of the American Rocket Society.

SPEAKMAN OF FAIRCHILD

Edwin A. Speakman, general manager of the guided missiles division, is a physicist, electronics engineer, and management expert. His experience in these fields includes the direction of a number of research and development programs of the Department of Defense. As vice chairman of the R&D Board, he was responsible for developments in electronics, guided missiles, aeronautics, and atomic energy. He is now serving as a special consultant in the Office of the Secretary of Defense.

He graduated from Haverford College in 1931, receiving his B.S. degree in physics. From 1934 to 1949, Speakman served in the research laboratories of Philco Corp., as assistant superintendent of the radio division and head of the Countermeasures Branch of the Naval Research Laboratory, with special scientific missions during the war.

Speakman

Hawkins

HAWKINS OF LOCKHEED

Willis M. Hawkins has had a hand in the design of just about every airplane made by Lockheed Aircraft Corp. from the Hudson on. For 12 years he was the Burbank manufacturer's chief preliminary design engineer, a post he moved into in 1941 at the age of 27. He has played a major role in development of the F-80, the F-94, the Constellation and Super Constellation, and more recently, the XFY-1 and the XF-104.

Hawkins is now chief engineer of the new Missile Systems Division, charged with the responsibility for the design of such missiles as may bear the Lockheed label. A native of Kansas City, he was graduated in engineering from the University of Michigan and engaged in a pre-engineering training course at Grumman before joining Lockheed in 1937.

PALLEY OF TEMCO

I. Nevin Palley, vice president of engineering, is credited with initiating the present Regulus concept while with Chance Vought.

He was also responsible for the direction of the F4U-5 and F6U-1. He initiated jet aircraft studies in 1942, which culminated in the development of the F7U Cutlass twin-jet fighter in 1946. He joined Lockheed, after graduating from Carnegie Tech in 1937, going from there to North American Aviation and on to Curtiss Airplane Company where he made the preliminary design studies of the first laminar-flow wing aircraft.

Since joining Temco, in 1954, he reorganized the engineering and electronics department into a single department on a weapons system concept.

Palley

Sandstrom

SANDSTROM OF BELL

Roy J. Sandstrom, vice president of engineering, has in his domain the vast program involved in Bell's guided missile and rocket propulsion responsibilities to the armed forces. Serving in various engineering capacities since joining the company in 1938, he was project engineer on the original X-1 chief, preliminary design engineer for developing new products, head of technical services, and executive chief engineer.

He is a graduate of the University of Michigan School of Engineering.

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West Coast Talk . . . By Fred S. Hunter

- **Only one truly supersonic plane?**
- **Hughes Tool does a big job quietly**
- **T56—a "bread and butter" article**

TONY LEVIER, the well-known author and test pilot, pitched quite a curve in a talk before the Los Angeles Lions Club the other day. Said Tony:

"We have only one truly supersonic airplane today, and it's so highly classified I hardly dare mention it. But I might say it's built by Lockheed."

What's Tony's definition of "truly supersonic?"

"An airplane capable of flying at supersonic speed at altitude," said Tony.

What altitude? Ah, there's the tickler. Tony shrugs. Altitudes are classified. How high is up? A long way up in this case, no doubt.

Tony, of course, was talking about tactical, not research, aircraft. He's been test-flying Lockheed's new lightweight XF-104, a whizzer which everybody knows runs through Mach 1. It's evident there's no doubt in Tony's mind that the new aerodynamic principles incorporated in the XF-104 enable it to do its Mach 1-plus stuff slightly out of reach of its competitors. On the other hand, there is the possibility that Tony, being steeped in Lockheed tradition, might be somewhat prejudiced.

* *

SPEAKING of Lockheed tradition reminds of a story. LeVier was flying Lockheed's chief engineer, Kelly Johnson, from Edwards Air Force Base to Burbank in the company's Beechcraft Bonanza and the airplane happened to do a little pitching in the turbulent air. After landing, Kelly turned to LeVier with a grin and observed: "What this ship needs is three tails."

* *

BOB SCHMIDT, manager of the Tucson Municipal Airport, was so impressed when a Douglas C-124 put in at his field to take on 6760 gallons of 115/145 gas—a record sale for delivery to one plane for the airport—he got out his pencil and figured that if you drove your car 20,000 miles a year and averaged 14 miles to the gallon that would be enough gas to last four years and nine months. Wait'll the jet transports come, Robert. Airlines already are asking oil companies how they can go about loading 80,000 pounds of fuel aboard a four-jet job for a nonstop trip from New York to San Francisco at 500 to 600 gallons a minute at low pressure. How's your computer come out on those loads?

* *

THE AIRCRAFT Division of Hughes Tool Co. recently completed a four-year program modifying B-25 bombers into radar fire control trainers for the Air Force. It was a big order and the kind of a job any other company in the business would have hastened to publicize as extensively as possible. Hughes Tool never said a word about it, even though the project did become known through the presence of the B-25's on the Hughes field at Culver City. The B-25's, incidentally, made ideal trainers for the Hughes fire control because they could be modified to provide seats for an instructor and five students, with radar scopes for each seat.

* *

U. S. AIRCRAFT manufacturers may think Capital Airlines blundered in ordering British Viscounts when there were good home-grown airplanes to be had, but they winced nonetheless. You don't laugh off 40-plane orders. . . . Workers at Lockheed quickly picked up Gen. Quesada's observation about a university atmosphere in the missile systems division and now refer to the Van Nuys plant as "the campus." . . . Word is out that Allison's T56 is a sure-fire "bread-and-butter" article for the General Motors division. . . . Douglas is spending $600,000 for six silencers for engine run-ups, two for the A3D, two for the F3D, two for the A4D. . . . Aerojet-General is pointing its expansion at its Sacramento installation, which it regards as ideally located for its type of work. It's specially good for test facilities because it has a minimum noise problem.

* * *

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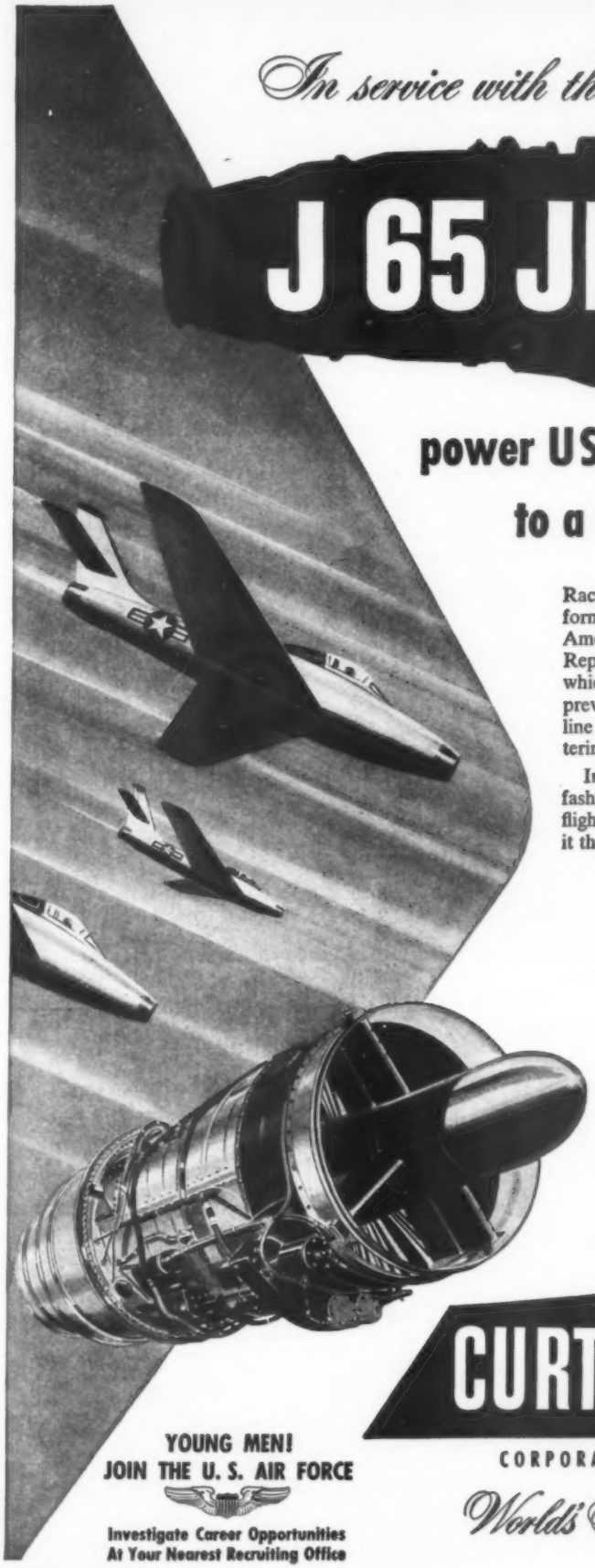

Racing 1900 miles from Edwards Air Force Base, California, to Dayton, Ohio, ten military aircraft competed for America's cross country speed championship. And the Republic F-84F Thunderstreaks, powered by J65 JETS, which swept first, second, and third places, all broke the previous course record. The winner flashed across the line at an average speed of 616.208 miles per hour, bettering the previous high mark by over twelve m.p.h.

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carrier-based attack bomber for the U. S. Navy

NORTH AMERICAN FJ-3 "Fury"
carrier-based fighter for the U. S. Navy

MARTIN B-57 "Night Intruder"
bomber for the U. S. Air Force

REPUBLIC RF-84F "Thunderflash"
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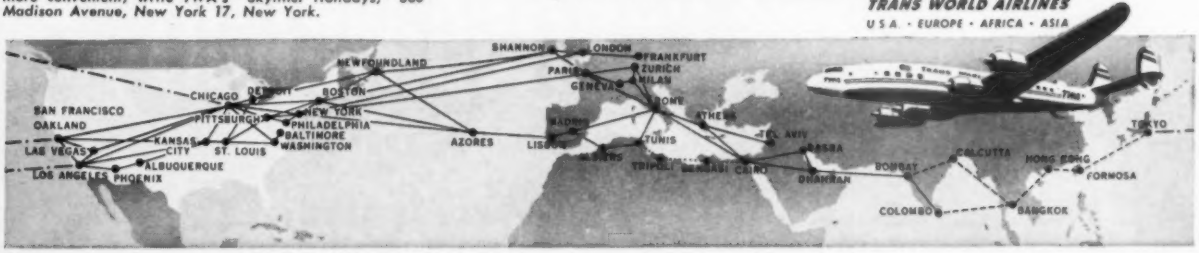

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Beechcraft

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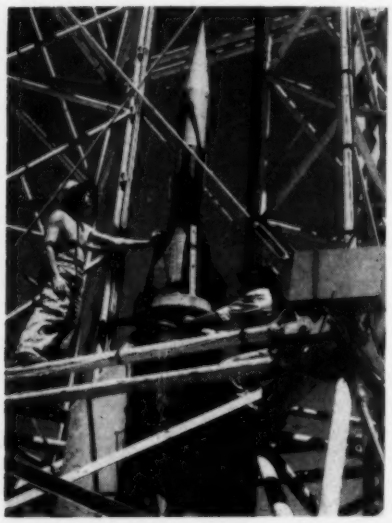
BEECHCRAFTS ARE THE AIR FLEET OF AMERICAN BUSINESS

MISSILES FOR RESEARCH

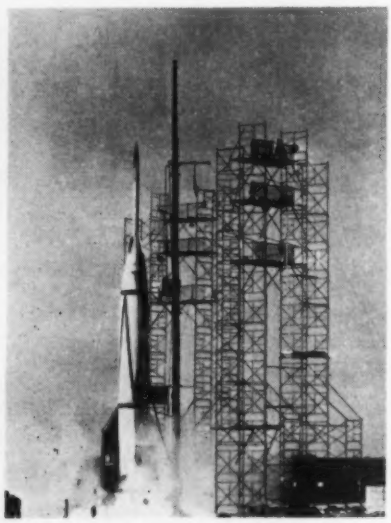
In a sense every missile developed by this country to date has been a research vehicle. And unless or until a war breaks out, this will probably be true for some years to come.

Some are more specifically designed for research than others. The Martin Viking, below, has set a world altitude record of 250 miles for two-stage rockets. Its telecommunications gear sent back to ground stations hundreds and perhaps thousands of signals tracing for the first time factual information on temperature, pressure, gamma rays, etc.

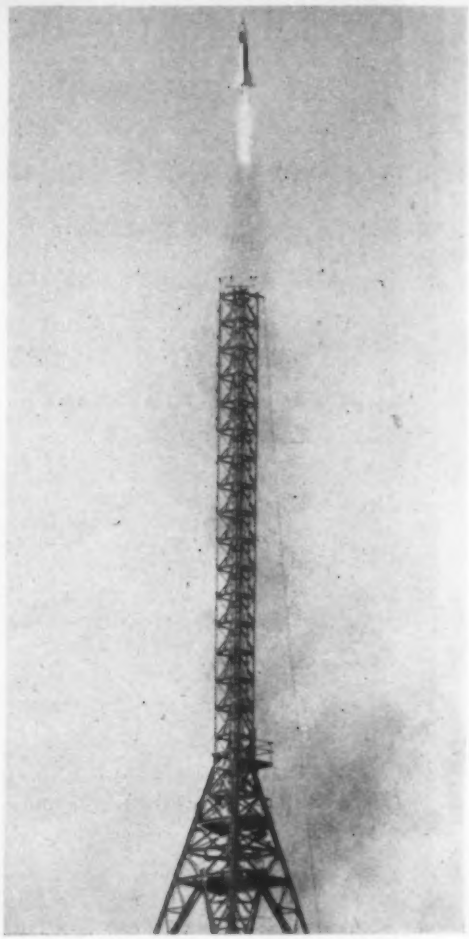
The Boeing Gapa is a different case. Compared with the dozen research Vikings which have been produced (some yet to be fired), over 100 Gapas were built and flown and it has served effectively as a forerunner of the more spectacular Boeing F-99 Bomarc.



Gapa: Powered by a ramjet engine, the Boeing Gapa used solid propellant rockets for initial acceleration to minimum ramjet speeds. An earlier version was rocket-powered. Considered the predecessor of the Boeing F-99 Bomarc.

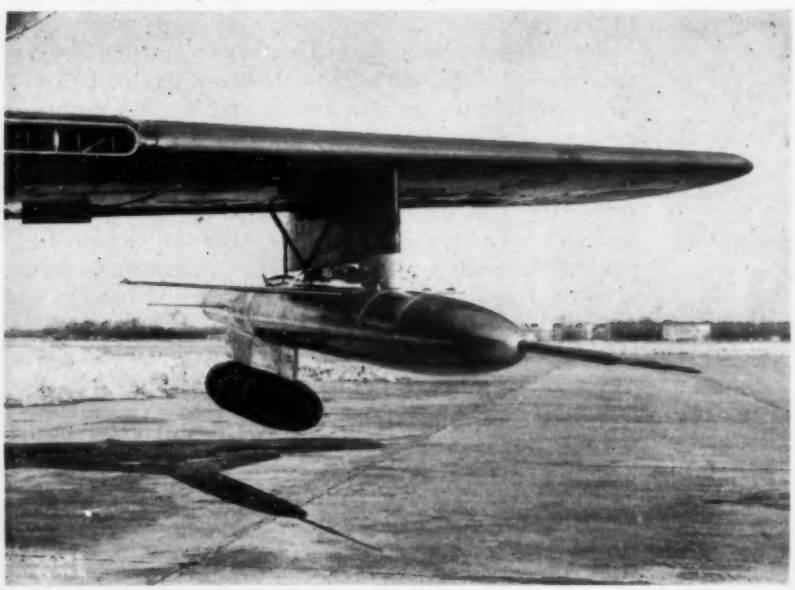


GE/Douglas Bumper: As the first two-stage rocket, the Bumper pioneered high-altitude rocket flight. It consisted of a Wac Corporal mounted on the nose of a German A-4 rocket, to be launched at 20 miles altitude.

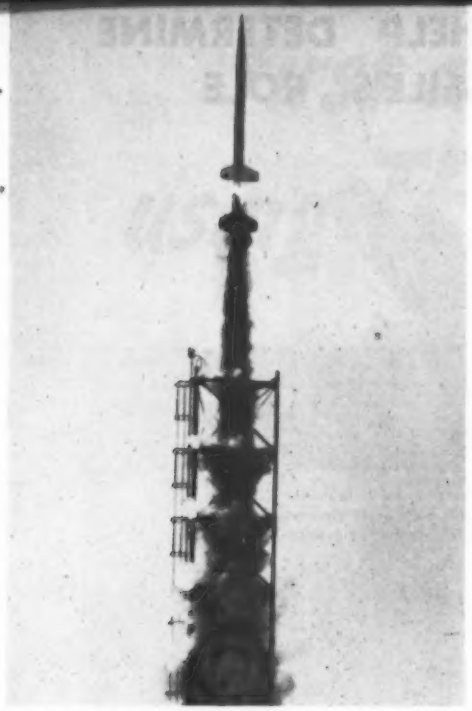


North American Nativ: This was a surface-to-surface missile launched from a 125-foot tower and reportedly capable of 50,000 feet altitude. It was used extensively for development of aerodynamic data in connection with control systems.

Martin Gorgon: The Gorgon represented one of the Navy's early attempts to use ramjet engines in missiles. At least six versions of the Gorgon were built prior to the current production model which is made by Fairchild and is radically different from these early models.



Martin's Viking rocket, one of a series of 12 built for upper atmosphere research, takes to the air. The Viking has been one of the leading rockets designed purely for research.



Aerojet Aerobee: An unguided rocket closely resembling the Wac Corporal but designed as a low-cost, high-altitude missile. A liquid propellant rocket, assisted by a solid-fuel booster, gave the Aerobee speeds of almost 3000 mph. Launched from 140-foot tower.

Fairchild Lark: A surface-to-air missile originally designed for the Navy immediately after the war. Was in production in the early '50's for general training as well as refinement of the Fairchild-developed homing system.

The fruits of research flights are highlighted by the case of the ramjet powerplant. The ramjet initially looked like a very simple engine, a false impression which led to the nickname "flying stovepipe." Three of these missiles, the Gorgon, Lark, and Gapa, were ramjet-powered. At this stage in ramjet development there was much to be learned.

These early lessons bore fruit. The industry found that the ramjet was in practice a complex piece of machinery, worth the development effort, but still in its infancy. Now practical missiles—the Boeing Bomarc, Bendix Talos, and the North American Navaho—are in advanced stages of development and production.

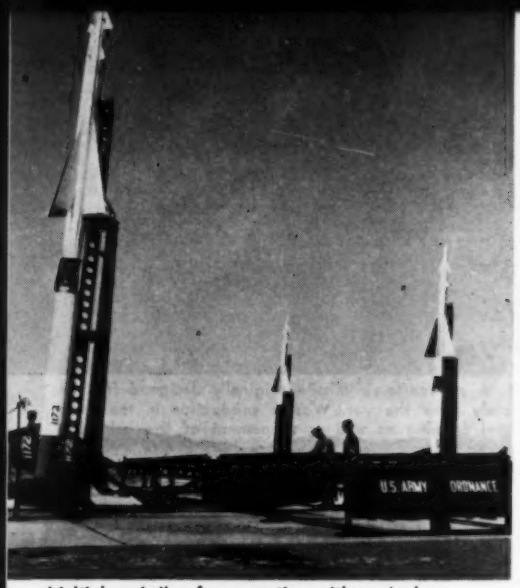
Many others, such as the General Electric Hermes, the Loon, Convair's MX-774, etc., made comparable contributions to the art.

RESEARCH, EXPERIMENTAL, AND SPECIALIZED VEHICLES

Manufacturer	Missile	Powerplant	Dimensions			Role	Remarks
			Length	Diameter	Span		
Aerojet	Aerobee	Aerojet L. P. Rocket	19′	16″	....	Surface-to-Air	Used by both USAF & Navy for research. Gross weight of about 1700 pounds. Finned body.
Boeing	Gapa	Rocket assist T.O., S. P.	19′	12″	3′ 6″	Surface-to-Air	Discontinued—more than 100 built. Reached speed of 1500 mph. Delta wing—4 fins. Ramjet test vehicle.
Douglas	WAC Corporal	Aerojet L. P. Rocket	16′	12″	3 fins	Research	Discontinued—used primarily for high altitude research.
Douglas/GE	Bumper	L. P. Rocket	62′	66″	....	Surface-launched research	Discontinued—combination of V2 rocket with WAC Corporal. One of eight built reached approximately 250 miles altitude.
Fairchild	Lark	Reaction Motors L. P. Rocket	14′ 5″	18″	Cruciform wings—6′	Surface-to-Air	Discontinued—two standard Aerojet JATO units used to assist take-off. Produced for the Navy starting in 1945 with USAF later getting limited numbers.
Grumman	Rigel	Marquardt Ramjet	....	....	....	Surface-to-Surface	An advanced ramjet-powered missile dropped because BuAer felt it was premature at present state of ramjet development.
Martin	Gorgon IV	Marquardt Ramjet	21′	....	....	Air-to-Air	
Martin	Oriole	Ramjet	....	....	....	Air-to-Air	BuAer development. Status indefinite but not active.
Martin	Plover	Marquardt Ramjet	22′	....	6′	Target drone	Discontinued.
Martin	Viking	Reaction Motors L. P. Rocket	41′ to 48′ (depending	32″ to 45″ on model)	4 fins	Upper atmosphere research	Program still active—a series of single- and two-stage rockets. The two-stage Viking set a world altitude record of 250 miles.
North American	Nativ	L. P. Rocket	14′ 6″	18″	4 fins	Surface-to-Surface	Discontinued—aerodynamic test vehicle. Launched from 125 ft. tower. Research for advanced missile control systems.
Ryan	Firebee	Fairchild J44 Turbojet	18′	....	12′	Drone, possible missile	Now in production as target drone with J44 powerplant. Some versions have Continental J69 engine. Ryan is seeking some type missile role for Firebee, probably as a surface-to-surface vehicle.
Ryan	Firebird	S. P. Rocket	7′ 6″	6″	Cruciform wings—3′	Air-to-Air	Discontinued—test vehicle for launching and homing systems. Used radar homing system to track target after being launched from plane.

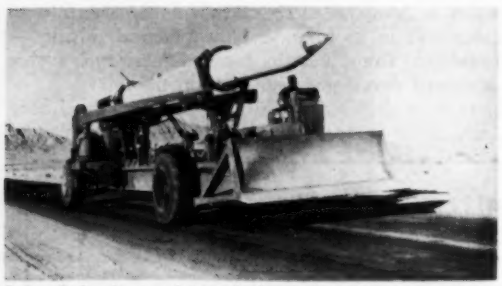
Code: L. P.—liquid propellant. S. P.—solid propellant.

LAUNCHERS HELP DETERMINE THE MISSILE'S ROLE



Multiple missiles for operation with a single radar battery is one key to Nike effectiveness and is simplified by this type launcher.

Photo of Maxson's new launcher (application still classified) stresses rugged simplicity and elevation control.



Role of the Corporal is such that it is apt to see service up front, off regular roads, and in virtually every kind of terrain. She's prepared.

Martin's Matador has been launched from this type trailer-mounted launch, from battleships and from submarines. She's mobile.

Missile launchers have become big business, and rightly so. The launcher does much to determine the utilization achieved with the missile. It determines mobility, contributes to firing accuracy, and may well control firing rates.

Shown here are some characteristic launchers and carriers for a variety of missiles. Some of the characteristics of each, as they would affect these factors, are immediately apparent.

As the major component of the U. S. continental defense, the Nike has a basic need for multiple firings. The controlling factor in Nike effectiveness is early detection of the enemy plane or missile and the opportunity to fire successive missiles, if necessary, to intercept it. Total missile flight time may be in the order of 100 seconds during which time the radars making up the command guidance system are occupied with this missile. The instant it hits the target, or a miss is apparent, the launcher must have another weapon ready to go.

The multiple missile positions on the Nike launcher assure this rapidity.

Simple ruggedness is apparent in the Maxson launcher.

Two approaches to mobility are shown in the dual purpose carriers and launchers handling the Firestone Corporal and the Martin Matador. Both are surface-to-surface missiles used by the Army. Note the Corporal's ability to level off its own launching site or to dig in, as the situation requires.

Much can happen to the missile between the production line and the front line. Chance Vought's answer to the transportability of its plane-sized Regulus Navy missile has proved quite effective.

Regulus is lowered into its shipping crates which forms part of the truck body . . .

Tailored cover for the Regulus, incorporating extensions for the folded wings, is lowered . . .

Off she goes. The Regulus is shown completely encased in the tailored "suit" which provides all-around protection.

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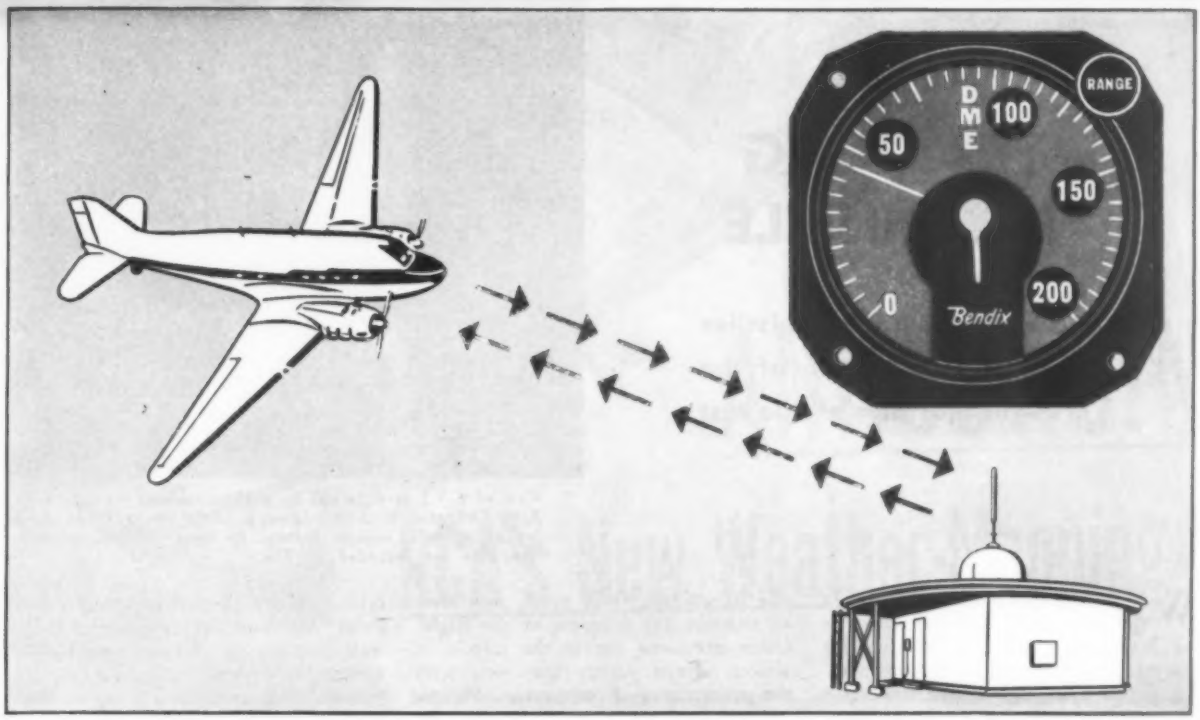

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TRACKING THE MISSILE

Gathering data on missiles in flight is a branch of the art which justifies all the rest

View of a V-2 as observed by a 35mm camera through a 10" Army Ordnance tracking telescope. Large image allows checking on attitude, exhaust pattern. At right, azimuth, elevation, and time are recorded on film.

WHATEVER TRUTH there is in the old saying that experience is the best teacher must be qualified for the missile engineer. For during an experimental firing the missile undergoes the experience, but it is the engineer who must be taught.

The various means of bridging this educational gap might be divided into two main groups:

- Optical devices like telescopes and cameras, which permit the watchers on the ground to see what happens to the missile.
- Electronic devices, like Doppler radar and telemetering systems, which enable the observers to "hear" what they need to know.

They may need to know a good deal. The location of the missile in three dimensions, its acceleration, its speed, and its attitude (roll, pitch, and yaw) all describe the progress of the flight. Other questions put to the missile in almost infinite variety may deal with the performance of components. Pumps, servomechanisms, timers, ejection devices—all may have pressures, temperatures, speeds, and voltages on which the engineer demands data.

Gathering such data makes up a branch of the missile art which is, at least until the shooting starts, the end and justification for all the rest.

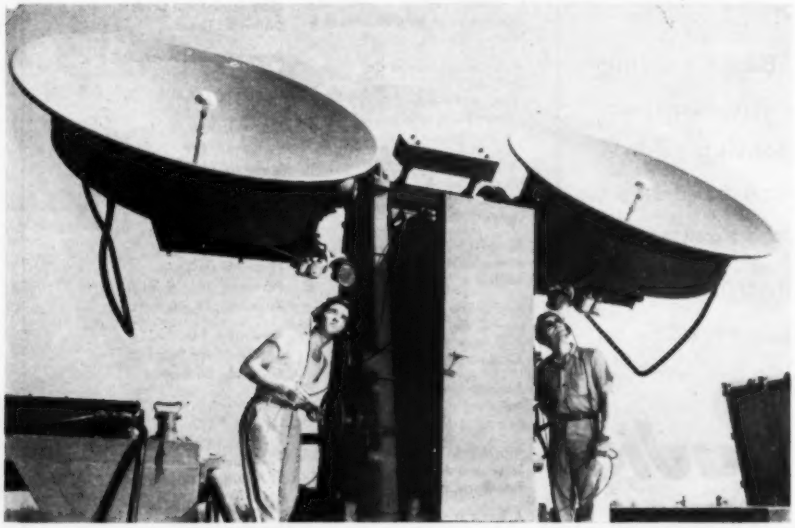
The job is no small one. During a typical five-minute flight, the Army Ordnance Corps, which operates the White Sands Proving Ground for all the services, will usually plot a missile's trajectory at half-second intervals. This means 600 points. The Navy Bureau of Aeronautics estimates that during a typical flight the telemetering equipment may pour out as many as half a million separate bits of information. Sometimes days or weeks may pass before the raw results of a firing are completely transformed into graphs and tables, depending upon the number of factors being checked and the manpower and equipment available for data processing.

For an airborne test of an air-to-air Falcon, a camera in the plane launching the missile, another in the Falcon, and a third in the target drone, plus search radar on the ground, may constitute most of the instrumentation. For tests of an intercontinental missile at the Air Force's missile test range which starts at Patrick AFB in Florida and may someday extend to the South Pole, the instrumentation would be proportionately more elaborate.

If no flight can be termed truly typical, the testing of the captured German V-2 rockets by the Army at White Sands has at least been extensive and suggests some of the problems involved in the field. During such a flight the missile instrumentation might be as follows:

During take-off, fixed "ribbon frame" motion picture cameras photograph the ascent in a series of tall, thin pictures, side-by-side on a strip of film. "Ballistic" cameras may also be used at this stage, as well as later, making a series of exposures in quick succession, all on the same photographic plate, so that in the finished photo the missile appears in as many positions as there were exposures. Since these cameras are fixed in position they are generally used only for the first portion of the flight.

As the missile pulls away from the launching site, search radar begins to plot its course on maps of the range. Range officers watch with one eye on



Doppler radar unit (continuous wave) tracks a missile at NACA's test range at Wallops Island, Va. Doppler systems gauge missile's change of position by measuring change in frequency of radio waves either bounced off missile or sent from beacon within it.

ANNOUNCING

RCA's New Weather-Mapping Ra

Airline operators have long sought a means of avoiding the time delay caused by storms across their routes, and for improving passenger comfort when storm penetration is advisable and practical.

RCA, in conjunction with major U. S. airlines, has developed a weather penetration radar system designed to "see" into storms and pick non-turbulent paths through or between them, making long and costly detours unnecessary.

This new system—RCA's AVQ-10 Weather Detection and Reconnaissance Radar—is the first airborne radar to use C-band (5.6 cm) transmission, the frequency best suited for "looking into" storms. It presents the pilot with an easily interpreted display of storm conditions surrounding him. The ground mapping feature, which it also offers, gives valuable terrain clearance information. It is conservatively designed to provide the reliability so necessary for airline operations. The five units included in the AVQ-10 (receiver-transmitter, accessory, antenna, indicator and control panel) weigh a total of about 133 pounds.

This is another example of the many important contributions that RCA has made and is continuing to make in the field of electronics. Every feature of the AVQ-10 is firmly grounded in RCA's electronic and engineering experience. Airline and private plane operators are invited to ask for more complete information.

COMMERCIAL AVIATION SALES
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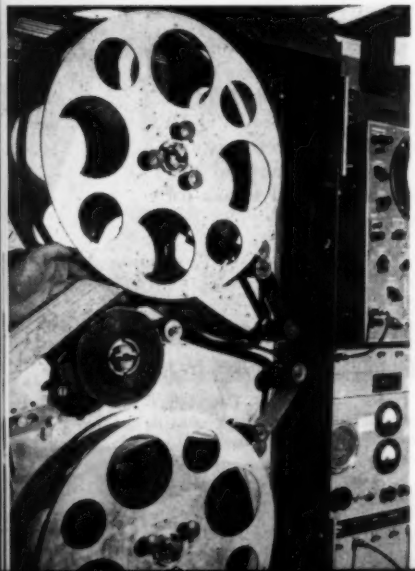
havior of components, converting these measurements into radio signals, and transmitting them to the ground stations.

While the electronic instruments are at work, men at the controls of telescopes of various sizes and degrees of accuracy are swinging their lenses after the dwindling image of the missile, with the direction and elevation as well as the picture of the missile recorded on high-speed movie cameras.

All the instruments are synchronized by a series of time signals from a central station, so that their records can later be compared. These time markers are generally transferred to the film records by small "blips" of light. After the flight the data-processing machines begin to digest the great mass of information that has been gathered on thousands of feet of film and tape.



Telemetering gathers bulk of missile test data. Compact sensing devices in missile gather data and transmit it to ground stations where it is recorded on tape or film for analysis. Above, test missile in NACA lab; below, coded information burned into specially treated tape at Boeing.

For an object which may travel at speeds as high as 10,000 mph, a question of considerable interest is always "Which way did it go?" Two varieties of telescopes are in wide use to answer this question—a ***tracking telescope*** which provides a large image, but only a fair degree of accuracy in pinpointing position, and a ***theodolite,*** which is a telescope-camera combination with high precision in position but a very small image.

The tracking telescope, first developed by the Ballistics Research Laboratory of Army Ordnance just after the war, can be used to keep a missile under observation for as much as 150 miles. Its large image allows observation of the missile's attitude, as well as of the changing shape and color of the jet exhaust, which fans out as the missile reaches high speeds and altitudes. When equipment is ejected from the missile, steering rockets fire, or segments of a "bumper" separate, these events can also be watched.

The largest tracking telescope built thus far (nine have been built at the Aberdeen Proving Ground in Maryland) has a 16-inch lens, a focal length of eight feet, and is mounted on a modified naval five-inch gun mount. Azimuth and elevation are accurate to within one mil. In the opinion of one Ordnance scientist, "It's about as large as we need to go."

A motion picture camera (a 35mm Eyemo and an Akeley have been used on different models) makes a film record of the observations of the tracking telescope. Part of each frame is the reflected image of dials indicating azimuth and elevation.

The big 16-inch model grew from a series of smaller models, including ones with 4.5-, 6-, and 10-inch focal length lenses. In achieving a large image, a long focal length is involved. With this goes the need for a large diameter objective lens, and a consequent increase in overall size. This tends to produce an instrument that is difficult to handle at the speeds required by missile work.

The photo-theodolite, known as the Askania, originally came from Germany and is one of the most widely used tracking instruments. American versions have since been built superior to the Askania in most respects, but most of these, like the tracking telescope, have been affected by the backlash in gear-driven counters for elevation and azimuth indicators.

Compared to a tracking telescope the theodolite has limited range. Both the American and German versions have been limited to about 25 to 30 miles. On medium- and short-range missiles, this has generally been more than enough to carry the "bird" at least past the point of burn-out.

Accuracy in the Askania is increased by the fact that azimuth and elevation are projected through a transparent 360° dial onto the film in the recording camera, avoiding the disadvantages of gear trains. Because of its short focal length (in the order of one or two feet) the image was originally relatively small. Two operators tracked the missile, one controlling elevation, the other azimuth.

No sooner was the Askania put into service in this country than its users began to look for ways to improve it. A joint project conducted by the Naval Gun Factory and Army's Ballistic Research Laboratory produced a long series of changes, including a different optical system, with one focal length of 14 feet instead of the original two feet and with other interchangeable lens with focal lengths of 60, 90, 120, and 170 inches. This improved version also is equipped with a film motor, the speed of which can be changed during the flight, so that slow-motion pictures can be taken at certain times (take-off, ejection of instruments, etc.). These speeds may be varied from 16, 32, or 64 frames per second. A rotating disk shutter, instead of a "venetian blind" type, gives greater flexibility in exposures. At least two of these new models have been installed at White Sands.

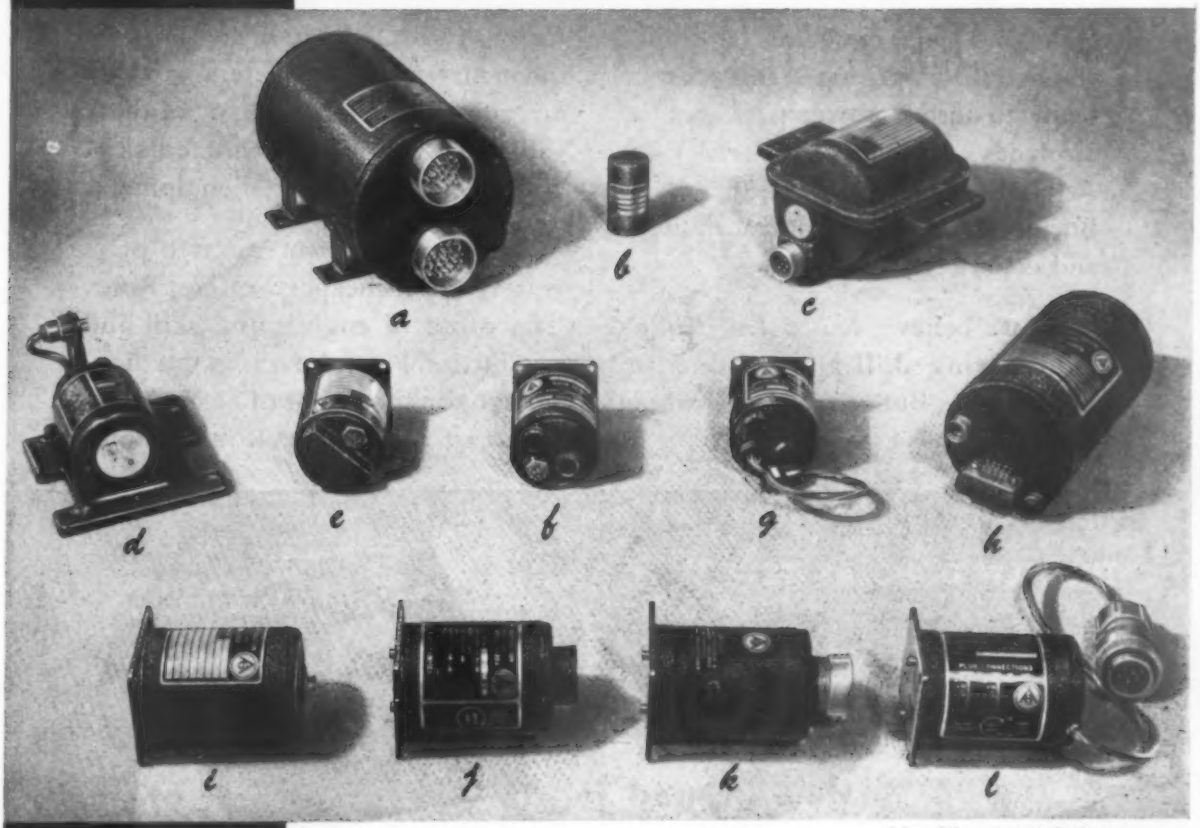
The joint effort of the Naval Gun Factory and Army Ordnance produced the Mark 3 Askania, currently in use, and the Mark 5, slated for early installation. The latter, according to the Navy Bureau of Ordnance, is a redesigned instrument to the point that only its lineage justifies use of the German name. Accuracy of angular measurements has been increased to six seconds, from the original 12 seconds, with the accuracy in terms of feet dependent upon distance to the target.

At Point Mugu, test center for the Navy's Bureau of Aeronautics, ground haze has been found to limit the effective range for trajectory measurement at low altitudes to about seven and one-half miles. High altitude missiles have been tracked for about 40 miles.

At the USAF's long-range missile test center at Patrick AFB, Florida, modified Askanias, used with search radar and cameras, are sufficient for providing information on trajectory, accelerations, and velocity. Tracking telescopes and Doppler radar techniques are used little, if at all. This choice of measuring instruments reflects the fact that tests at Patrick are long-range flights, where mid-course velocities need

MINIATURE CONTROLS

GYROS–ANGULAR ACCELEROMETERS–INTERVALOMETERS–CONTROL SYSTEMS



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J. S20A RATE GYRO
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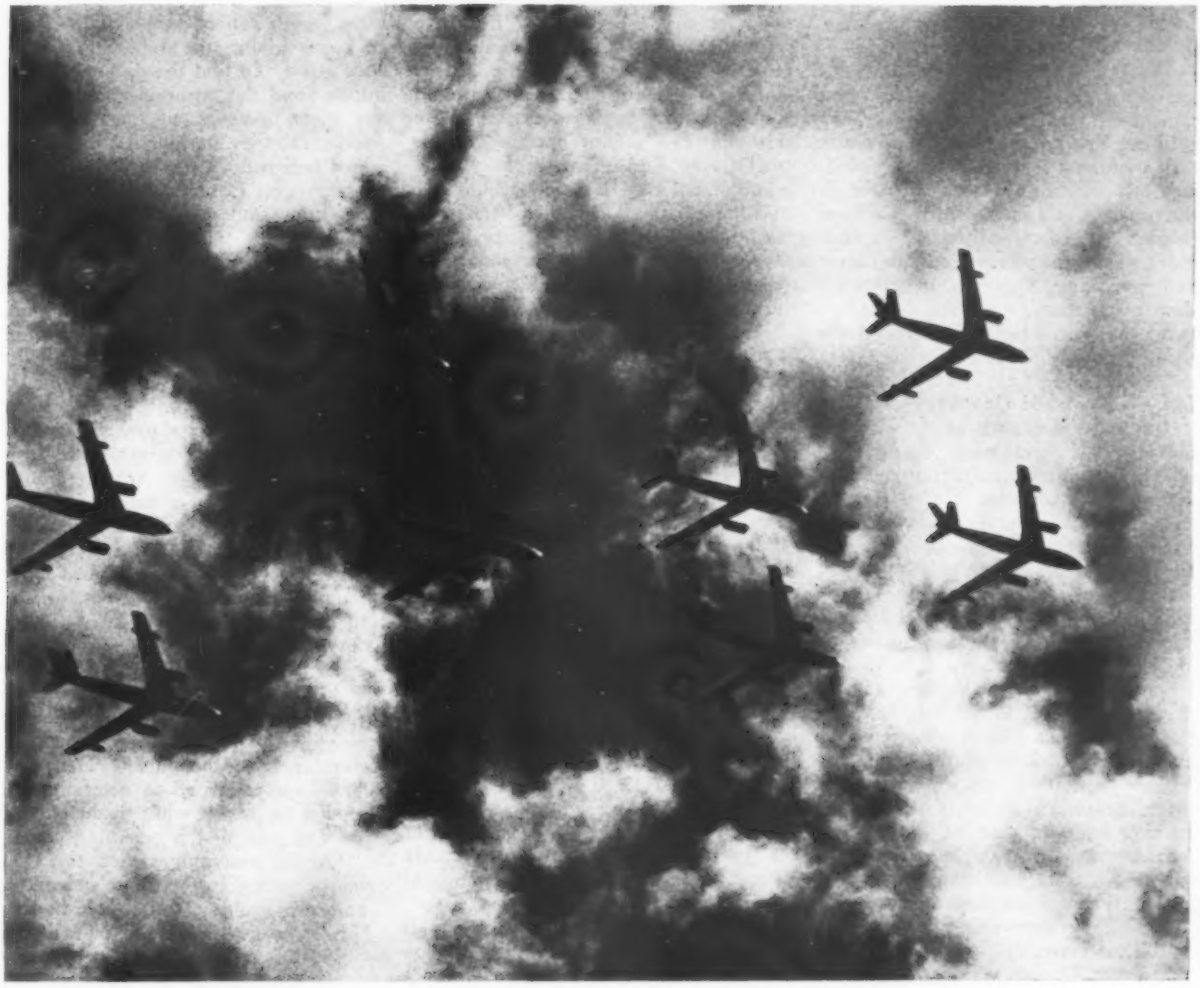


Salute to America's first all-jet bomber force

At Barksdale Air Force Base, La., late in July, the Second Air Force became America's first all-jet striking force with retirement of the last of its piston-driven bombers.

Now completely equipped with fast Boeing B-47 Stratojets, the Second Air Force is part of Strategic Air Command, America's global air arm. Its swept-wing Boeings are 600-mile-an-hour medium bombers that have broken all existing distance and endurance records for jet aircraft, including a nonstop trans-Pacific flight with aerial refueling from California to Japan.

Strategic Air Command continually flies training missions that simulate exacting combat assignments. Ranging the skies over three continents, the polar ice cap and vast expanses of ocean, SAC aircraft follow split-second timetables. Their trial bombing runs, defense and other maneuvers are all scored in a relentless drive for ever-increasing proficiency.

Entire wings, numbering 45 Stratojets and 20 Boeing KC-97 tanker-transports, are rotated regularly through scheduled training operations to English and North African bases. On these missions, tanker-transports provide aerial refueling for the jet bombers, and carry the ground personnel and equipment needed to make each unit self-sustaining for 30 days.

SAC is on an around-the-clock combat alert. Its operations have achieved such a high level of efficiency that its training missions could be transformed instantly into massive retaliatory action against the war-making power of any aggressor, anywhere.

Establishing America's first all-jet striking force marks a giant stride forward in this nation's defense program. The advance is continuing as additional Strategic Air Command units complete their transition to all-jet operations.

Young men: You'll acquire "know how" as an airman in the United States Air Force. Opportunities for top technical schooling, world travel and a responsible position on the nation's defense team.

BOEING

not be known with the same precision that other tests demand.

One difficulty with all optical systems—Askanias, tracking telescopes, cameras—is that an overcast sky, or even one cloud in the wrong spot, limits their usefulness sharply. What is needed, says one Air Force spokesman close to the problem, is a radar which will have enough precision to replace optical means, permitting firings despite clouds and providing a means of allowing down-range stations to "acquire" (lock onto) the missile easily as it passes into their territory.

Radar at present takes two main forms—*search* and *Doppler*.

Search radar, such as the SCR-584 anti-aircraft gun-laying equipment which transmits a 10-centimeter pulse, is generally adequate for plotting a quick and rough trajectory. It can be used to monitor the missile during its flight, with its position shown constantly on a scale map of the range. This allows the operators to make sure that the missile is not straying beyond the boundaries of the test area. If it is, a detonator can usually be exploded within the missile to destroy it.

At Wallops Island, Va., center of missile test work for the National Advisory Committee for Aeronautics, a truck-mounted SCR-584 is used in connection with an observer tracking the missile manually through an open gunsight. Since its establishment in mid-1945, Wallops has launched approximately 2500 test vehicles of all sorts, and it is currently firing at a rate of 300 a year. Of this workload about 80% is pure research into the problems of supersonic flight, which may be applicable to either aircraft or missiles.

The 584 radar at Wallops is controlled by the "remote" operator (usually no more than a few yards from the main unit) who is needed because the radar will not lock onto the missile while it is on the ground, due to ground clutter. When the missile rises above this clutter a second operator in the truck-trailer flips a switch to "Automatic" and the unit locks onto the missile and follows it automatically for the rest of its flight. This may be 10, 20, or 30 miles, or, on infrequent occasions, as much as 200 (firings are directed out over the Atlantic).

Movie cameras, with radar and telescopes, keep record of tests. Above, a camera is mounted to shoot through the antenna of SCR 584 search radar at Wallops. Radar plots trajectory as missile flies.

The range of the 584 was originally a little over 18 miles, but modifications have stretched this to almost 55 miles. Accuracy of the position data fed from the radar's selsyns is roughly ± 200 feet, but within 20 miles a target as large as a plane can be tracked within ± 50 feet.

The limitation of search radar is its accuracy. "Search radar may be all right for position," says L. G. de Bey, chief of the electronics measurements branch at the Army's Ballistics Research Laboratory at Aberdeen, "but for design work the engineers want accurate measurements of velocities and accelerations. Our measurements are usually taken with continuous wave Doppler systems at half-second intervals, but we sometimes go to 1/10 or 1/500 of a second. You could conceivably get search radar to an accuracy of ± three feet, but in 1/500 of a second a missile may only have moved two feet, so you would have no accuracy at all."

Consequently, a Doppler system is used by BRL, not to measure position in space (at which it has an accuracy of about ± 10 feet) but to measure change of position, which it does with an accuracy of ± 1.2 feet. Even this might be increased with further development to an accuracy of two or three inches at a distance of 100 miles. The accuracy of the change-of-position figure is not affected by the distance of the missile from the ground station.

Such a system is made possible by the fact that the frequency of a signal sent out from a ground station to a moving target will change when it is reflected back, or when a transponder inside the missile replies. The difference in frequency between the outgoing and returning signals is proportional to the speed at which the target is moving toward or away from the station. The difference in frequency (called Doppler frequency, or "beat") is measured by mixing the basic ground signal and the signal received.

The wave length of the 38.5 megacycle signal which BRL uses is 12 feet. A difference of one cycle in the signal returning from the beacon in the target therefore represents a change of position of 12 feet. The accuracy of the system is such that the reading on each wave length can be broken down into 10 parts, giving the 1.2-foot accuracy cited above. To find the distance of the missile from the transmitting station at any given moment all the individual position-change increments must be added together.

A recent Doppler unit, the Model 10C, is now under consideration at Wallops Island by the NACA, which has not yet accepted it from Sperry. This version is mounted on a 90mm gun-mount, is adapted for one-man tracking, and can be completely servo-controlled from the search radar. Accuracy in determining acceleration of the missile is described as being within one percent.

NACA's Doppler use is based on reflections from the target, since it is short-range work. The Army (through BRL) makes use of a beacon, or transceiver, within the missile. This unit, originally designed for use in the A-4 missile (the German V-2), has a range of approximately 100 miles, with an output power of about 10 watts.

On the ground, two receivers are needed at each station—one to receive the 38.5 reference signal identical to that being sent to the missile, the other to receive the 77 megacycle signal that is returning from the missile. These two signals are compared to determine the Doppler frequency, which is then amplified and sent to the recording station.

At the recording station the Doppler frequency is applied to a bank of cathode ray tubes mounted side by side. The traces are then photographed by a 35mm camera. Onto the film also goes a time record in the form of light blips at 10 millisecond intervals.

Telemetering

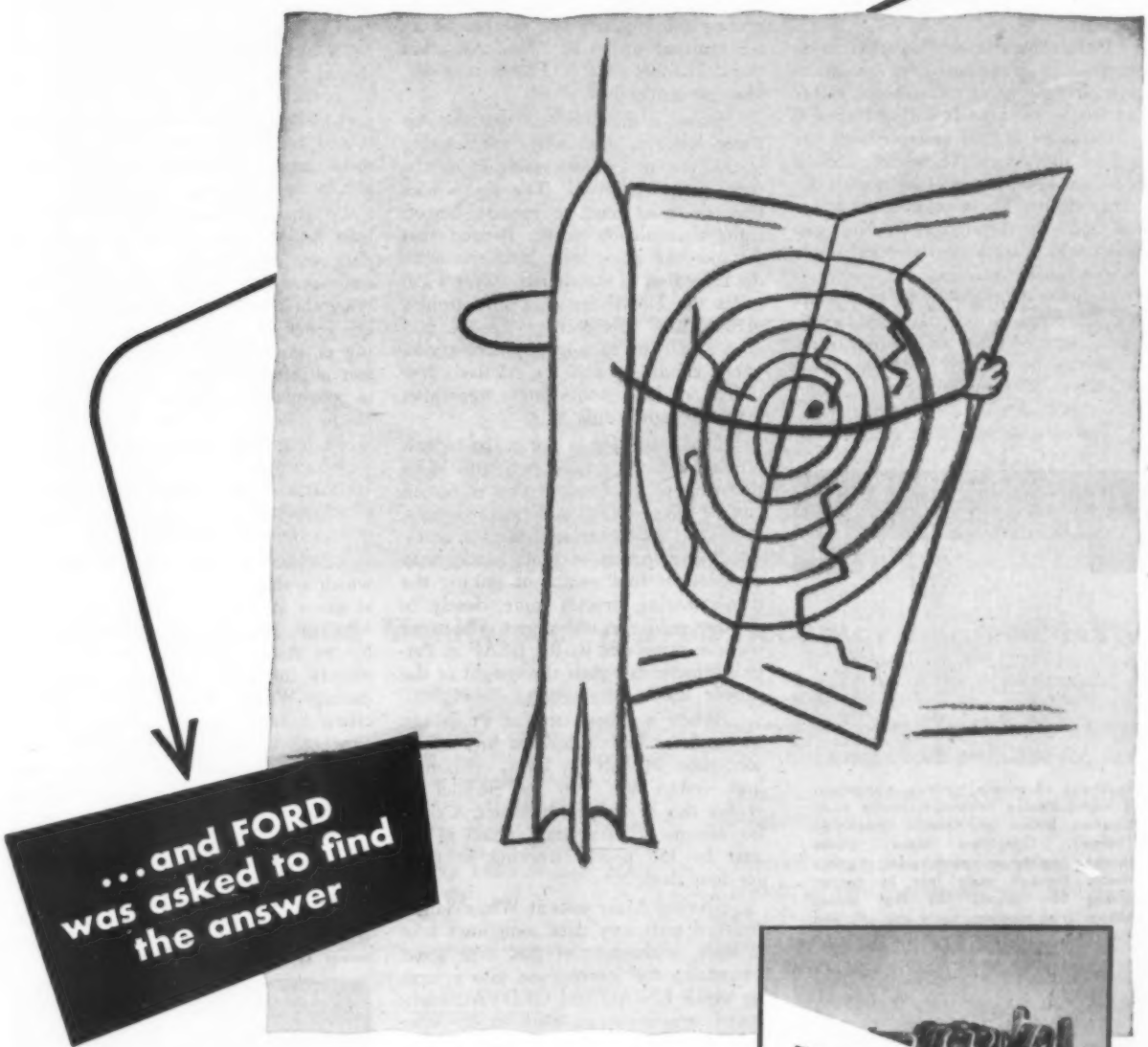
Standard commercial equipment is widely used by the military in telemetering, in the transmitters as well as in the receiving and recording equipment on the ground. There are two basic types of transmission:

- FM/FM, which uses frequency modulated subcarriers.
- PW/FM, which uses pulse-width modulation.

In the former, information is transmitted in terms of variations of frequency. The sensing instruments in the missile transform readings on temperature, pressure, etc., into a series of varying frequencies, which are transmitted to the ground. Amplitude modulation, if used, would be subject to interference from noise and fading. These conditions do not affect transmission when frequency modulation is used.

Maximum capacity of the system is in the neighborhood of 14 channels, if each channel monitors one instrument continuously, as is required by some types of data. If the data from a given

HOW TO TEACH A MISSILE
to read a map



Zwish! And off goes a missile. But where? And how to stay on the right track? And how to *find* the target? That's the problem Ford Instrument is helping to solve.

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instrument can be gathered periodically, rather than continuously, a channel can take information first from one instrument, then from another. This is known as commutation. When the signal from this channel is received on the ground, the information from the various instruments that are taking turns on it is separated.

In the "pulse-width" system the information is transmitted by means of variations in time of transmission rather than frequency. Signals lasting from 600 microseconds to 900 microseconds are used by the Army. These are received on oscilloscopes as bars of light with different widths. These widths are measured and run through computing machines, which translate the widths into the appropriate readings.

Tabular data as well as graphs are then furnished to the engineers. In this system about 30 different sensing instruments may be checked 30 times a second, thus collecting 900 bits of information per second.

The total of such data naturally increases as the flights become longer, as well as with the number of instruments checked. At Pt. Mugu, with flights lasting half an hour, half a million points may have to be plotted in processing the telemetered information. Here the Navy generally uses from four to six channels of FM/FM type, with two or three operating continuously and the remainder commutated up to 30 times. An additional channel of PW/FM is available, also commutated 30 times.

Some of the problems that the Air Force has run into in its telemetering operations at Patrick result from the long ranges involved. The frequencies that are used tend to require line-of-right transmission range. Beyond that distance the noise level interferes with the recording of the signals. Beyond 150 miles the USAF has run into trouble getting any telemetering signals, and even at 60- to 80-mile distances atmospheric conditions and the relatively low power of the transmitter sometimes make reception difficult.

Data reduction is one of the biggest problems of the missile program. With the mass of information that is turned out by telemetering and other devices, automatic reduction of data is a necessity. Programs are currently under way designed to find means of linking the data-gathering process more closely to the data-reduction techniques. The paper work accumulated by the USAF at Patrick sometimes equals the weight of the missile itself.

When a missile test at Pt. Mugu accumulates half a million bits of information in half an hour, computers and coders are run in parallel to reduce this in a matter of hours. A similar volume of data was handled in the past by 150 people working in pairs for four days.

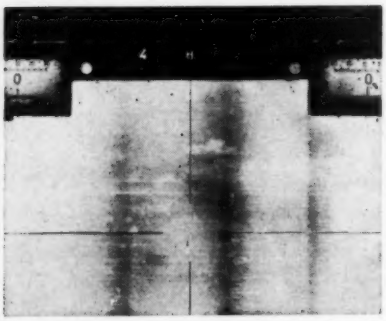
During Army tests at White Sands, finished trajectory data sometimes take a week, with most of that time spent in putting the information into a form in which ENIAC and ORDVAC high-speed computers can work on it. After this handwork is done, it takes a computer only about 30 seconds to plot an individual point on the trajectory, going through some 40 mathematical steps in the process. Actual computing time may amount to only an hour and a half. This schedule represents a 10:1 improvement over earlier manual methods, and improved precessing machines are well along in development.

The vital importance of this phase of the missile program is suggested by the fact that to a large extent the firing program is paced by the rate at which data can be put into usable form and analyzed. If three missile firings a week are scheduled and the data from the first takes a week to be reduced, the lessons learned from that firing will not be available for the other two.

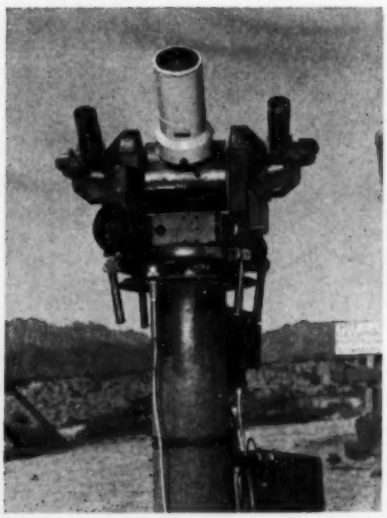
The goal at present is development of a system which will give useful data (if not an exhaustive analysis) while the missile is still in the air, so that changes in operation can be fed to the missile as a result of information gathered. The result of such a system would be a considerable saving in time and money. The USAF is now working on a "quick look" technique, by which a preliminary consideration of the data would be made, after which only the most significant portions would be completely analyzed.

Perhaps the most accurate, but the least flexible, instruments for gathering data on missile flights are the fixed cameras which ring the launching sites. Since their field of view is limited they are generally used only on the launching or impact stages, up to about 8000 feet altitude. They may make a series of separate exposures at a rate of from 30 to 180 per second. At the slower speed a typical frame would measure 5.25 by 0.9 inches. Narrower "ribbons" are taken at the higher speed. Motion of the missile can be stopped by an exposure time of 0.0001 second.

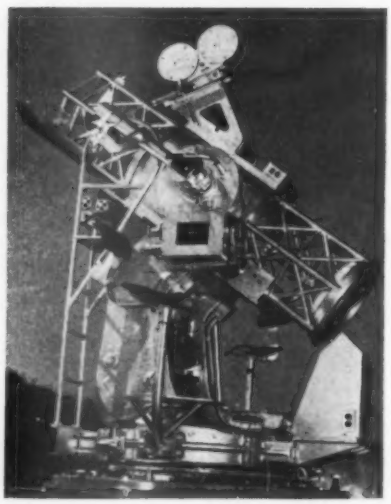
Ballistic cameras are also used, in which a single plate or film is exposed as many as 300 times while the missile is within the field of view. Developed by the Army's Ballistics Research Laboratory for work on bomb trajectories during World War II, this high-precision camera has an accuracy in daytime use of one part in 75,000. It is even more accurate at night, since these cameras are oriented by observations of the stars. • • •

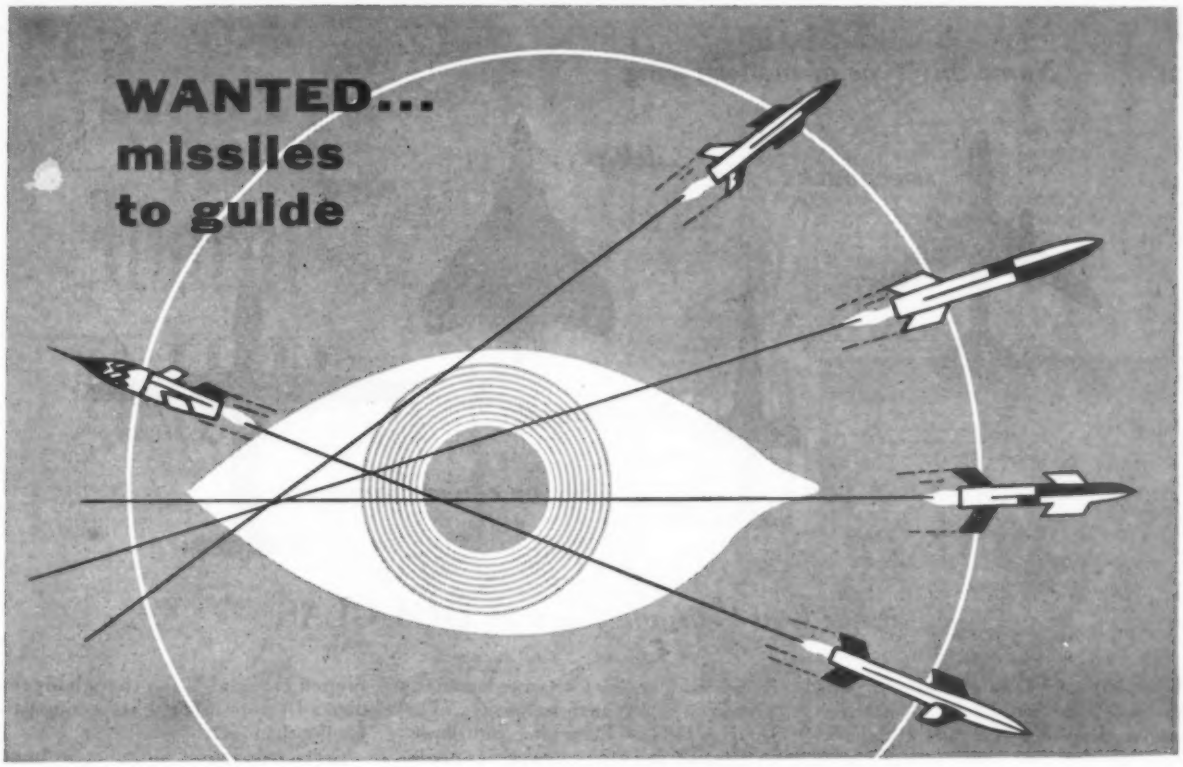


Backbone of missile tracking equipment is high-precision telescope-camera combination known as Askania theodolite (below). Operators track missile through sights on each side; camera shoots through main lens in center, giving film record like that shown above. Dial readings show azimuth and elevation.



Biggest yet 16" tracking telescope developed by Army gives large image of missile on camera film (see photo, p.100), compared with smaller image from Askania theodolites. Modified 5" naval gun mount serves as base.





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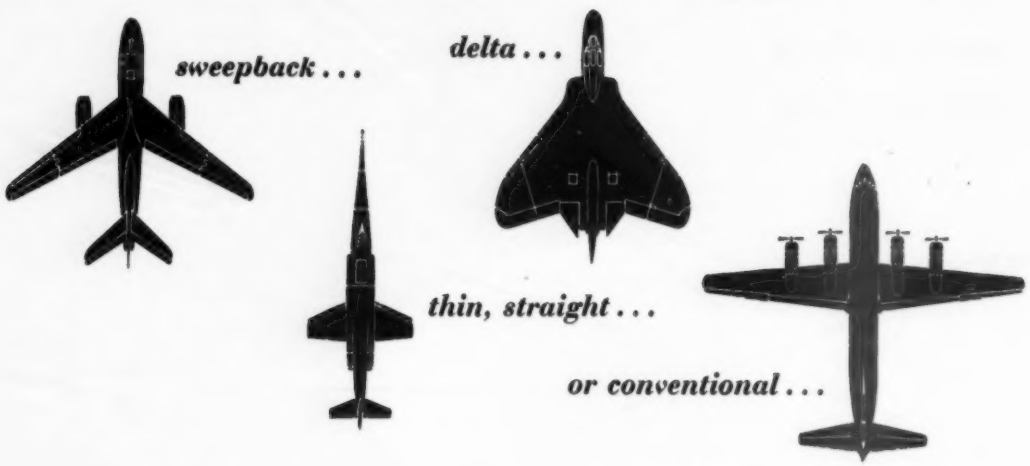

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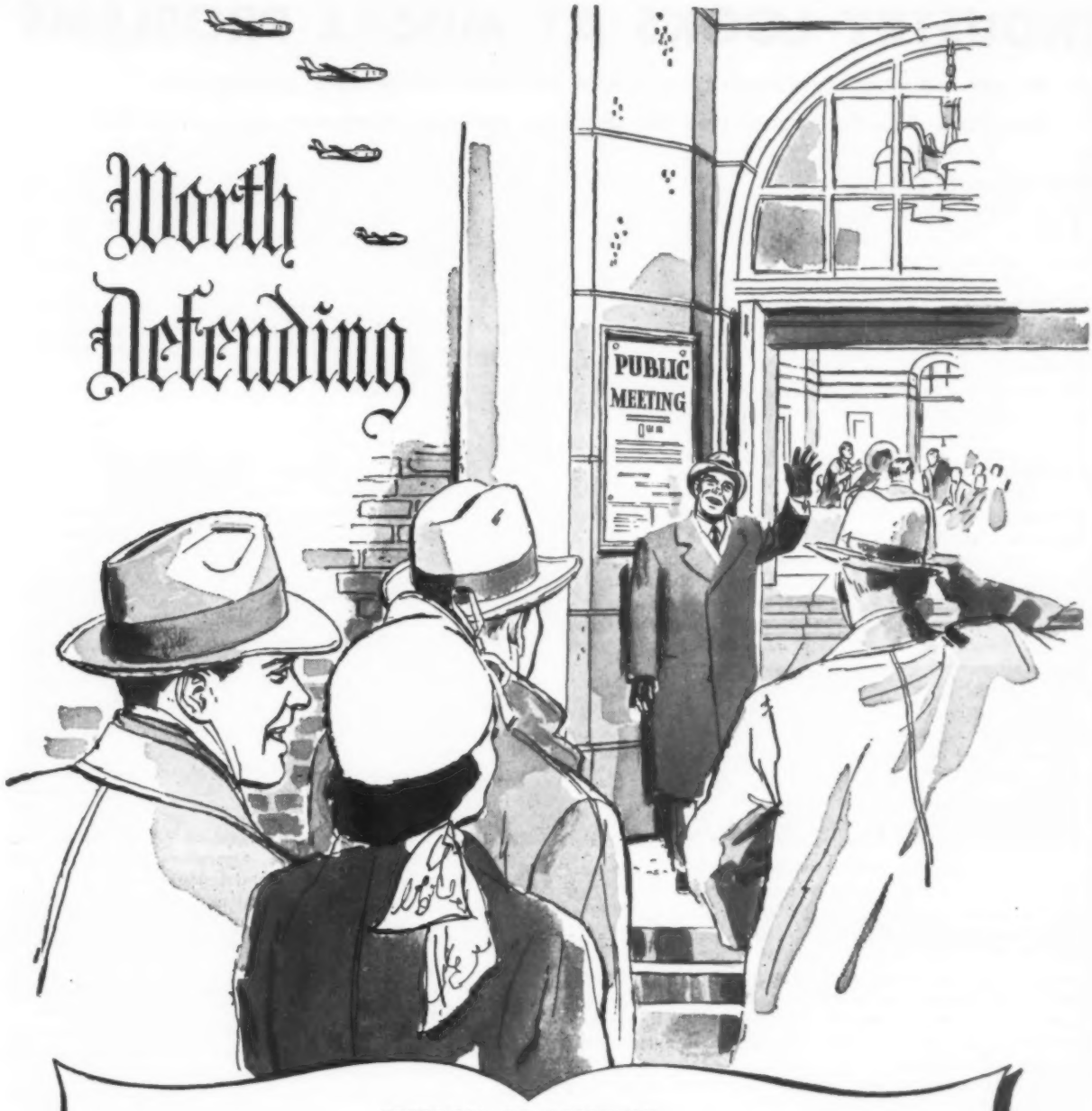

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INDUSTRY LOOKS AT MISSILE PROBLEMS

To get industry's viewpoint on major problems of missile production, American Aviation conducted an industry survey—Here are some answers . . .

Bell Aircraft Corp.

THE FUNDAMENTAL PROBLEM at this time in the guided missile field, is removal of the gap between present missile performance and 100% reliability.

Demand for utter perfection in any other field is usually considered unreasonable. But in the case of guided missiles, the reliability of each part is more an essential than an optimistic goal. Assuming all parts of a missile to have a reliability of 99.5%, the effectiveness of a missile having 100 parts would be only 60%. Increase the number of parts to 500 and the reliability drops to about 8% and with 1000 parts, the figure becomes less than 1%.

Reliability

While the current goal is increased reliability, the greatest advances in the past several years have been in that same direction.

One of the original concepts dictating the design of various systems and components which comprise a guided missile was that of the "one shot" philosophy. It was felt that design or quality could be cheapened because the end-product would have a relatively short life, measured in a matter of minutes or hours.

Experience has proved that this attitude is completely unjustified. The conclusion has now been reached that because a missile is unmanned, it must have an inherently higher degree of reliability because there is no pilot to exercise judgment and correct for minor errors and malfunctions.

Components

To provide the desired degree of end-product quality assurance, it has been necessary to conduct functional tests on "Christmas tree" type of hardware. This means that individual parts (e.g. electronics tubes, hydraulic valves, transformers, etc.) are tested before being assembled into components. Components such as amplifiers, power supplies, and rocket engine thrust chambers are then tested before assembly into their respective systems. Finally, the systems themselves are installed in the airframe and the entire missile is tested compositely.

This type of testing is usually begun on an extensive basis in the case of a new design or a major model change. In the course of time statistical analysis of test data will indicate that certain tests can be eliminated.

The chief difference between a missile test program and testing a piloted aircraft is that the latter is not expendable. One or two experimental prototype airplanes may be flown dozens of times and hundreds of hours. Such aircraft can be modified and tested repeatedly, thereby producing an almost inexhaustible amount of data. This will also precede production line, whose major problem is to incorporate the results of experimental flight test at convenient break points.

A successful guided missile may require more than 100 prototypes to develop an operational configuration. This presents a tremendous problem. Although a large number of airframes is involved, appearing like a production line, they are, for the most part, painfully different from one another.

In addition to having design differences to demonstrate different flight characteristics or trajectories, the results of the firing program must be fed back into the line.

The changes which have a bearing on safety or the primary objectives must be incorporated before the next firing. This creates extreme problems for production, engineering, and those responsible for establishing schedules.

Time is of paramount importance. The military need for starting production lines is acute. Consideration must be given to the opposing problems of schedule necessity and the benefits to be gained and the risks assumed in dollars and time with each succeeding development flight.

Electronics

In the field of electronics, progress in the development and improvement of basic parts has been remarkable. New parts are smaller, lighter, more reliable and will operate in extremes of environment unheard of a few years ago.

The best production gyroscopes now available have drift rates measured in small fractions of a degree per hour, compared with several degrees per hour a few years ago. Complete automatic guidance systems, actually more accurate than is required with the latest warheads, are well advanced.

One of the continuing problems is that associated with aerodynamic heating at hypersonic speeds. Outer shells of advanced missiles may be subjected to temperatures in the region of 2000° F to 4000° F, requiring the use of special temperature resistant materials. In order to minimize weights, insulation or cooling of primary structural members must be studied.

Increasingly important in airframe construction is the provision of adequate structural rigidity. Future missiles will require ever thinner air foil sections to attain desired performance. Using wing thickness of 4% to 6% of the chord, rigidity demands are superseding structural limit loads as the determining structural design criteria.

Accordingly, the structural engineer must design for a certain number of degrees of torsional deformation at the tip of the wing under load or the number of degrees of body bending.

Advanced missile configurations will continue to stimulate the development of new structural materials.

Probably the greatest advance of all was begun recently with the leasing of contracts for the study of the basic principles of design of rocket engines and injector heads. When these studies have been successfully completed, rocketry will advance from an art to a science.

Republic Aviation Corp.

FURTHER IMPROVEMENTS in missile system performance will be realized through improvements in the design of components, improved materials, and more efficient propellants. These improvements will be obtained only as a result of intensive research and development work at a rate which will appear slow in the light of developments in the guided missile field during recent years.

Reliability

The problem of taking the delicate hand-built, pampered, control mechanism used in today's laboratory missiles and redesigning it to make it suitable for mass production is truly a major one. The degree of reliability, tolerances on operating characteristics, and range of specified operating conditions required from these mass-produced components will test the ingenuity of the designer, the laboratory technician, and the production engineer.

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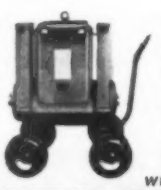

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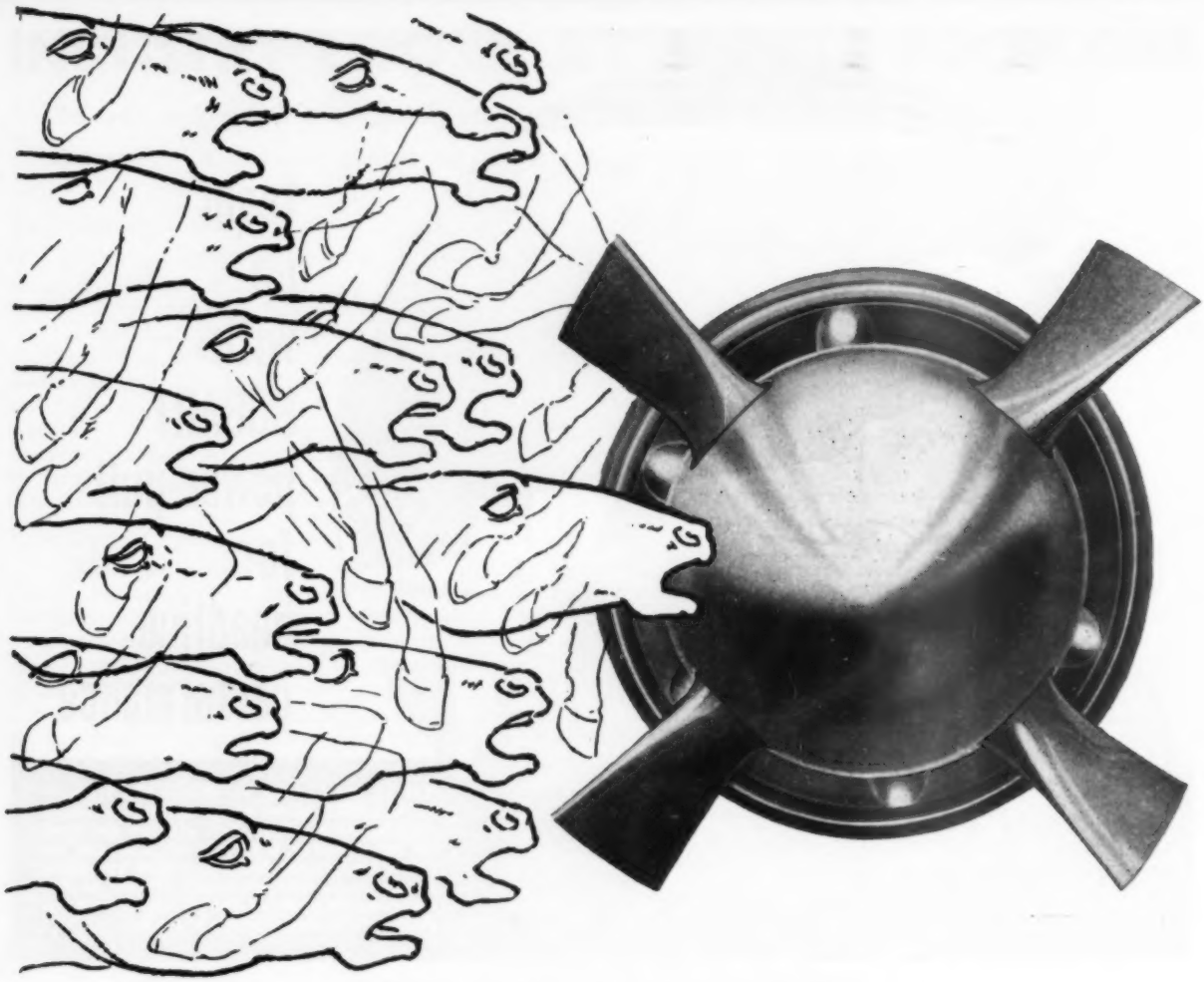

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INDUSTRY LOOKS AT PROBLEMS

In the design of new missile systems, the knowledge obtained to date will make it possible to establish systems specifications which will reduce the operating demands on the components and make it possible to obtain the desired degree of reliability with greater economy.

Simplicity

In event of national emergency, neither time nor the skilled personnel required for maintenance of complex electronic equipment is available in adequate quantities. Hence, in system design, reliability and simplicity of maintenance should be major goals. Where the required complexity of the equipment overtaxes the capabilities of the operating and maintenance personnel, provision for automatic test equipment and the development of routine checkout and maintenance procedures must be considered essential extensions of the basic missile design process.

Mobility

The most serious operational problems must be met by the designer of the surface-launched tactical support missiles which require a very high degree of mobility and can tolerate only a minimum amount of support equipment in the field.

Due to the expendable nature of the guided missile and the short time of flight, there is a definite lack of flight experience available to use as a basis for correcting design deficiencies. This has made it necessary to develop extensive simulation equipment and complex data collecting methods.

Despite these developments, it should be recognized that a backlog of operating experience is essential as a basis for design improvements and this can only be obtained through extensive flight testing programs.

A sound guided missiles industry requires a long-range procurement plan by the armed services which will permit the R&D effort to continue at a level to maintain our technical leadership in the field. This is essential if the industry is going to attract and hold the highly specialized engineers required.

Successful R&D programs must also be supported by production facilities, production tooling, and limited production runs to insure the feasibility of production and provide adequate weapons for service test under simulated conditions and stockpile.

Initiative by industry in developing improved designs, processes, and manufacturing techniques should be encouraged and efficiency of operation should be directly reflected in profit.

The Glenn L. Martin Co.

TO THE QUESTION "where do we go from here?" the traditional aeronautical answer is faster—farther—higher. These advances will come, and there is no doubt of their desirability; but let us pause a little before rushing headlong into the traditional pattern established by our missiles' manned counterpart. Missiles have demonstrated they can navigate to a target but they have not yet demonstrated that they can do this as reliably, consistently, and economically as the airplane. This does not necessarily mean that the airplane is still technically superior; it simply means that the human pilot makes up for a lot of airplane deficiencies.

Environment

This "design for use" represents an even greater challenge to the missile designer today than the need for more speed, range, or payload. The missiles and their associated checkout and test equipment must be made useable when subjected to service handling and must successfully withstand air, truck, and rail transportation, warehouse storage, and shipboard or ground handling environments under battle conditions. The necessary assembly and test procedures must be simplified to the point where they can be performed by average technical ratings presently within the services. Checkout operations, where impossible of elimination, must be streamlined to a "Go-No Go" basis.

The systems must, under conditions of service environment, be highly reliable of operation before they can effectively replace or supplement existing weapons. In this regard the missile designer has a doubly difficult problem. Only very recently have components begun to become available which will withstand the conditions of environment to be encountered in such applications. This is particularly true in the area of electronic tubes and associated resistors and capacitors, but is almost equally applicable to valves, relays, connectors, motors, actuators, propellants, etc. It is important that the components selected for a particular system be thoroughly type-tested under the anticipated environment and an adequate margin of safety demonstrated before they are included in the design. The designer does, however, have control of what perhaps is the largest single factor in reliability; namely, simplicity. He must continually resist the temptation to try to achieve some slight increase in performance or accuracy at the expense of a disproportionate increase in complexity and loss of reliability.

Producibility

The second major area of problems facing the missile system designer involves that of producibility. If missiles are to take a major place in the weapons field, they must do so on the basis of economical effectiveness. They must accomplish the desired mission for less overall dollar cost than other alternate methods. The designer will do well to consider his missile the ammunition for the system rather than the gun itself.

To assure producibility, it is necessary to design for it in the early developmental stages of a program. Every consideration should be given to the use of mass production tools and methods such as circuit printing, dip soldering, die casting, spot and flashwelding, furnace brazing, etc., in the early designs. It is then possible to substitute for those methods to suit the quantity at hand without sacrificing the ultimate producibility of the product. Incorporation of machine-controlled processes not only reduces unit costs, but also increases reliability by providing more consistency from part to part than it is possible to obtain from human labor, however skillful. Consideration should be given to the use of the various techniques for "automation."

One often-neglected facet of the producibility problem is the use of non-strategic material. The same might be said for critical tooling. The use, for example, of large extruded aluminum sections, capable of production on only one or two presses in the country, would seem shortsighted. A frequent tendency of designers of missile systems is to concentrate their efforts on the more romantic part, the missile itself, and to do only a perfunctory job on the supporting equipment. They must be made to realize that the same order of producibility, reliability, economy, and operational suitability must be incorporated in the checkout and ground-handling equipment and other system elements if the system is to be operable as a tactical weapon.

McDonnell Aircraft Corp.

MANY highly technical missile problems have been solved in the past 10 years. A large number still remain. New problems have been uncovered almost as fast as solutions have been found. For example, solution of propulsion and other problems so as to permit hypersonic speeds

has brought to the forefront the many problems of aerodynamic heating.

Reliability

This seems to be the only major problem in the way of acceptance of several missiles as complete military-usable weapons. The chief offenders in this regard are the electronics components, although a few projects have been plagued with propulsion problems, vibration and shock problems, and material problems. (See page 64)

The basic reliability problem in electronic equipment is not one of circuit design for the electrical engineer but one, oddly enough, of detail mechanical design. Lack of appreciation of missile environments, coupled with an almost unreasonable pressure to make the electronic packages light and small while having miraculous performance has produced a situation which we consider alarming. Slowly, however, mechanically ruggedized components are becoming available and substitutes for many of the most unreliable components are appearing.

Guidance

Guidance now forms practically the only major limitation on new missile designs with the possible exception of materials. It is an engineering possibility to build almost any type of missile, except for the lack of an adequate fund of actual knowledge in how to reliably provide the corresponding performance in an automatic guidance system.

Materials

Advance to hypersonic speeds will depend on the availability of suitable high-temperature materials. At present, the only reasonable material which can be used for a Mach 5 missile is stainless steel, and even this material has probably lost too much of its strength for a prolonged flight at Mach 7. Titanium, which is now being used in supersonic manned aircraft, loses its strength-weight advantage at a Mach number of about 4. Some of the more exotic metals, such as tungsten, molybdenum, and tantalum, which hold promise of performing at the extreme temperatures, are far too costly to be used in one-shot weapons.

Other problems which face the guided missile industry are:

- Development of basic theory of hypersonic flow and means for making adequate aerodynamic tests.
- Development of basic theory of aerodynamic heating and means for verifying such theory by suitable tests.
- Development of higher impulse rocket fuels and rocket motors to decrease the tremendous size and, hence, overall costs of certain missiles.
- Missile production will require increased emphasis on new tooling and production techniques. The numbers of missiles to be ordered in production will exceed the normal number for manned aircraft and yet not approach the rate or total number of units produced by the automotive industry. The optimum balance must be struck between completely automatic manufacture with a minimum of manual operations and the more or less job runs utilized in the inhabited aircraft field. • • •

Ryan Aeronautical Company

The pilotless aircraft field covers a range of sizes and missions, starting with target drones of perhaps 1000 to 1500 pounds gross weight, requiring engine thrust of less than 1000 pounds, and extends all the way up to intercontinental bombers comparable in weight to a piloted bomber.

Airframes

Missiles which are designed for a single flight and are to be expended at the end of the mission do not have the requirements for repairability which we design into our piloted aircraft. The balance of production and operating costs against allowable weight and the required degree of aerodynamic cleanness must be viewed from the standpoint of the specific mission and operating conditions.

The missile category should require less in the way of safety precautions than we require in a piloted airplane. However, there is a requirement for greater reliability in all the functional parts since there is no human pilot to compensate for a failing component. The general problem of reliability is one of the major problems facing all missile manufacturers.

The so-called thermal barrier is not a definite thing such as the sonic barrier. Rather it is a gradual increase in temperature with speed. A great deal of effort is being expended on the development of new materials for airframe use in the high temperature missile. The problem extends much further than the structure. Electronics equipment now malfunctions at temperatures as low as 200° F. and at these temperatures the life of many items of equipment is very short. Normal fuels are unsatisfactory for use at high temperatures and it is difficult to provide adequate fuel cooling. Some warhead materials become unstable and dangerous at comparatively low temperatures.

Propulsion

The turbojet engine is a relatively complex and costly piece of machinery, but for many applications it appears to be the logical powerplant for missile use. A number of attempts have been made to develop an expendable turbojet engine. It has been found that an engine which is thoroughly reliable for a period of from one to 20 hours—a normal life requirement for a missile engine—can be made reliable for a long period with little additional effort. The prospect of having a really cheap and expendable turbojet engine is not bright.

Guidance Systems

Problems in the field of missile guidance are probably the most serious in the whole missile field. For short-range operation it is possible to resort to radio or radar control. The techniques for this type of control have been in use for some time and are now well worked out. This type guidance, obviously limited by the range of the radio or radar system, is also subject to interference and false commands from many sources.

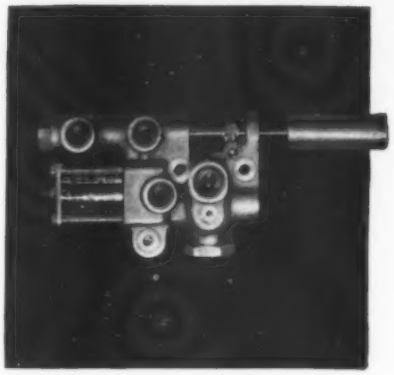
In long-range missile applications—more than a few hundred miles—it is necessary to resort to control which is not related to ground control equipment. This might be done by straight dead-reckoning but would require the accurate prediction of all disturbing influences (such as wind variations), and would require more accurate launching and control systems than appear practical.

The dead-reckoning system can be improved considerably by installing space references in the form of inertia units (such as very accurate gyros). Even with these precise instruments the system is still faulty since the inaccuracies increase with distance traveled. Divergence could be eliminated by use of celestial reference and the system can be made convergent by homing on the target itself.

Launching

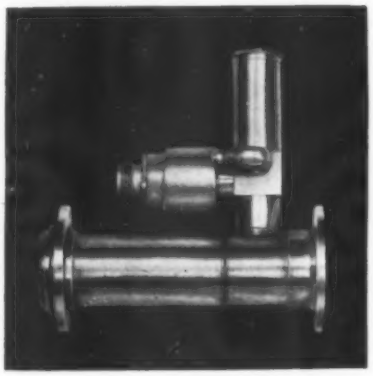
Many missiles are launched by means of rocket power, but it is not always realized that the cost of the rocket device, with a useful life of only a few seconds, may amount to as much as 10% of the total missile cost. This, of course, is a cost for each launching and is in addition to the rather elaborate installations involved. Rocket-type launching appears to be the most practical method of getting a missile into the air. In some high-performance missiles we are approaching a thrust-to-weight ratio of one. When this figure is exceeded it may be possible to eliminate the rocket cost by using vertical take-off on the missile engine thrust alone.

• • •



JANITROL CANOPY SEAL REGULATOR automatically inflates a sealing tube around canopy base when it is closed—maintains proper pressure differential in the seal to keep the canopy airtight, yet ready for immediate failure-proof release in emergencies!

AIR PRESSURE CONTROLS



JANITROL HIGH PRESSURE REGULATOR picks up jet engine compressor bleed air (as high as 200 psi and 750F) and reduces the variable pressures to a controlled 12 psi under all flight conditions, sub or supersonic!

Automatic control of air and fuel variables is one of the basic engineering skills at Surface Combustion Corporation. Successful application of these skills to non-combustion problems (typified by the air pressure controls described opposite) may mean help for you. We invite your inquiries, on both combustion and/or air handling problems.

37 years experience in combustion engineering

Janitrol

AIRCRAFT-AUTOMOTIVE DIVISION
SURFACE COMBUSTION CORPORATION
Columbus 16, Ohio

District Engineering Offices: New York, 225 Broadway; Washington, D. C., 4650 East-West Highway; Philadelphia, Penna., 401 No. Broad St.; Kansas City, Mo., 2201 Grand Ave.; Fort Worth, 2509 Berry St.; Hollywood, Calif., 7046 Hollywood Blvd.; Columbus, Ohio, 400 Dublin Ave.

Missile Product Progress --- Electrical

Micro-Clutch

Mfr.: Magtrol, Inc.
Size: Dia.-63/64", L-2⅛" (including shaft extension)

Used as a clutch or brake in missile applications. Capable of transmitting 8 ounce-inches torque with a control current of 65 milliamperes.

Time Delay Relay

Model: 6400
Mfr.: The A. W. Haydon Co.
Weight: 1 lb.
Size: L-2¾", W-2-7/32", H-3-9/32"

Operates on 28 volts, has up to six channels and can function from 1½ seconds to 2 hours. Used to provide time delay periods for multiple functions in missiles. A motor-driven timer relatively free of environmental problems.

Battery

Model: 20HR85V
Mfr.: Yardney Electric Corp.
Weight: 70 lbs.

100 ampere-hours capacity at 500 amperes, 30 volts output. Rechargeable. Features flat output voltage and high current drain capabilities.

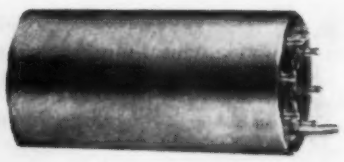
Battery

Mfr.: Yardney Electric Corp.
Weight: 134 lbs.

A multiple unit providing 230, 6 and 600 amperes output and rated at 40, 1, and 100 ampere hours. Rechargeable.

Accelerometer

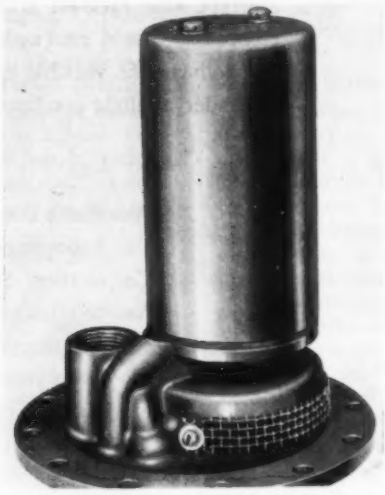
Model: SA-A5
Mfr.: Sanders Associates, Inc.
Weight: 3½ oz.
Size: 2-inches high



Operating on 26 volts, 400 cycles, the SA-A5 has a 5g range and is used in telemetering and missile and air borne platform stabilization. Output angle 1.5 degrees. Operates under static or vibration g's.

Fuel Boost Pump

Model: RG-11260
Mfr.: Lear, Inc.—Lear-Romec Div.
Weight: 4.2 lbs.
Size: Dia.-5¼", H-6⅛"



Direct drive ⅓ horsepower submerged boost pump operating on 27 volts d-c. Uses centrifugal type impeller to maintain bubble-free flow even during fast climb. Pumps 200 gph at 19-20 psi. Used on Ryan Firebee.

RPM Control Switch

Model: KC-223
Mfr.: Kahn and Co., Inc.
Weight: 44 oz.
Size: Dia.-2½", H-4½"

Controls rotational speed by making or breaking the electrical circuit at preset valves from 500 to 5000 rpm. Can operate external relay to open or close two direct-acting circuits—such as magneto circuits.

Subminiature Blower

Model: Minicube
Mfr.: Sanders Associates, Inc.
Weight: 1 oz.
Size: L-1", W-1", H-1"

Operates on 6 volts or 26 volts at 400 cycles producing 3 cubic feet of air per minute for cooling missile electronic equipment.

Air Pump

Model: RR-9870
Mfr.: Lear, Inc.—Lear-Romec Div.
Weight: 35 lbs.
Size: L-16-29/32", W-6⅛", H-11⅜"

Oil-free dry air pump with 10 cfm capacity at 8 psi discharge. Uses 1¼ horsepower geared motor. Used in ground check cart to test fuel system of Martin B-61. Equipped with micronic filters on inlet port, adjustable relief valve on discharge port.

"O. K. To Jettison!"

The force ejection pylon designed, developed, and produced by Pastushin assures safe, positive ejection of jettisonable fuel tanks and other external stores at any speed or possible flight attitude.

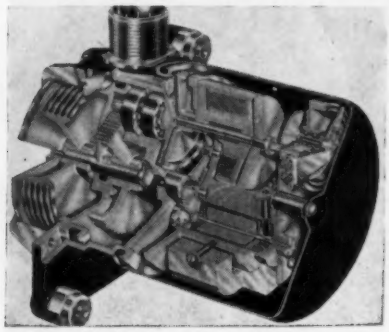
PASTUSHIN AVIATION CORP. • Los Angeles, California

RESEARCH • DESIGN • DEVELOPMENT • PRODUCTION

Unusual opportunities for engineers! Submit resume.

Servo Actuator

Model: 205
Mfr.: Summers Gyroscope Co.
Weight: 4¾ lbs.
Size: Dia.-3¾", L-5-7/32", W-4¼", H-5¾"



Operates on 28 volts d-c at 1.75 amps producing 200 inch-pounds torque at 44 degrees per second. Torque to inertia ratio 200,000 rad/sec²; 10 milliseconds acceleration time constant. Torque loads maintained with only intermittent application of input powers.

Circle No. 19 on Reader Service Card, page 155, for more information.

Sealed Thermostat

Model: C4344
Mfr.: Metals and Controls Corp.
Weight: 4 grams
Size: Dia.-⅝", H-41/64"

Operated by Spencer Thermostatic disc, relatively unaffected by shock and vibration. Rated at 5 amps at 30 volts a-c; 2 amps at 125 a-c and 1 amp at 250 volts a-c. Hermetically sealed. Factory set at temperatures ranging from minus 10°F to plus 400°F.

Circle No. 54 on Reader Service Card, page 155, for more information.

Silvercel Battery

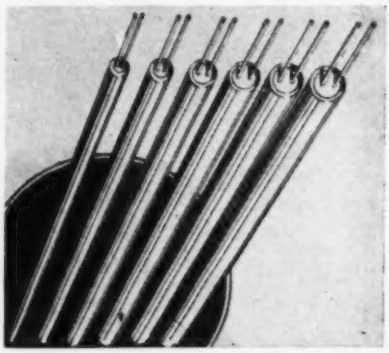
Mfr. Yardney Electric Corp.
Weight: 2 lbs.

About 1/6 the weight and 1/5 the volume of conventional batteries, the Yardney Silvercel is a rechargeable multiple unit with two different voltage, current, and capacity power supply requirements. Capacity 1±3 ampere hours. Output 4±10 amperes.

Circle No. 90 on Reader Service Card, page 155, for more information.

Insulated Thermocouple

Models: 1092-1097
Mfr.: Aero Research Instrument Co., Inc.
Size: Dia.-.04" to .32", L-up to 25'



A swaged MgO insulated thermocouple with capacity up to 2000°F. This insulation forms a high temperature protection for thermocouple wiring and entire assembly is swaged into a stainless or inconel tube.

Circle No. 116 on Reader Service Card, page 155, for more information.

Rotary Actuator

Model: 249
Mfr.: Lear, Inc.—Grand Rapids Div.
Weight: 7.35 lbs.
Size: L-8.8", W-5.5", H-3.4"

Operates on 26 volts d-c with 5000 inch-pounds output at two rpm. A rotary actuator of variable travel,

the Model 249 is used to fold the fins on a missile. Load-sensitive actuator de-energizes when loads reach a predetermined point, thus protecting the missile structure from momentary gust loads during fin-folding.

Circle No. 73 on Reader Service Card, page 155, for more information.

Converter

Model: Super
Mfr.: Carter Motor Co.
Weight: 13 lbs.
Size: Dia.-4½", L-8⅝", W-4½", H-5"

Power supply for operation of electronic measuring instruments. Operates on 5.5 to 230 volts d-c producing 115-volt 60-cycles a-c. Rated to 150 watt continuous 60 cycle output.

Circle No. 35 on Reader Service Card, page 155, for more information.

Level Switch

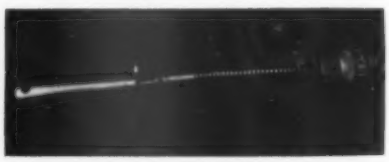
Mfr.: Avien-Knickerbocker
Weight: 1.70 lbs. (dual), .85 lbs. (single)
Size: Mounting head (double) 4.6"-W x 7.1"-L. Depth varies with installation.

Operating on 28-volt d-c at 0.13 amps, Servel level switch employs a bridge circuit activated by a standard a-c or d-c power supply. Precise control of valves for controlling valve operation, refueling pumps, tank switching, etc. Has no moving parts.

Circle No. 13 on Reader Service Card, page 155, for more information.

Thermocouple Probe

Model: T-1006
Mfr.: Aero Research Instrument Co., Inc.
Weight: 10 oz.
Size: Dia.-⅜", L-6"



High-temperature exhaust gas thermocouple probe for temperature up to 2000°F with time constant of one second or better. Output 0.022 mv/°F. Senses tailpipe temperatures to an accuracy of 1/2 of 1%. Available in special materials to extend range to 2500° with short duration up to 3000°F.

Circle No. 46 on Reader Service Card, page 155, for more information.

UNDER ONE ROOF
By James J. Haggerty, Jr.
(No. 1 in a series)

"Government Plant No. 6 in Marietta, Georgia, is a new wonder of the industrial world"

Says James J. Haggerty, Jr., Aviation Editor, Collier's Magazine

If a list were made of the seven industrial wonders of the world, there is little doubt that one would be U. S. Government Aircraft Plant No. 6 (GAP-6) in Marietta, Georgia.

GAP-6 is the world's largest integrated aircraft plant *under one roof*. Operated for the U. S. Air Force by Lockheed since 1951, it builds six-engine B-47 jet bombers and modifies hundreds of other B-47's to keep them up to date. It produces Lockheed C-130 turbo-prop combat cargo planes, yet it still has room to make other, bigger aircraft in its massive B-1 building—all *under one roof!*

You get the same feeling of incredible size when you step inside GAP-6 in Georgia as you do when you first see Grand Coulee Dam, or the Empire State Building, or the Pentagon. It's the "under one roof" that makes this bigness important. There is no loss of time, no costly delay in assembly, manufacturing or tooling, for all facilities are as close as the nearest telephone. One example of its size: 70 miles of fluorescent tubing are required above its 76 acres (yes, *acres)* of floor space.

When used to capacity, GAP-6 can have four production lines—each for a different big plane.

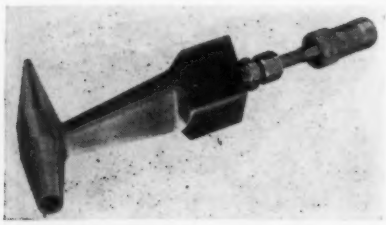
U.S. Air Force
Govt. Aircraft Plant No. 6

Lockheed
Aircraft Corporation
(a Lockheed advertisement)

Georgia
Division, Marietta

Stagnation Thermocouple

Model: T-1086
Mfr.: Aero Research Instrument Co., Inc.
Weight: 14 oz.
Size: L-4.5", W-4", H-1"



A fast response stagnation thermocouple probe for sensing total temperature on high-speed missiles. Designed for Mach 3.5 operation with accuracy of 0.5% or better.

Circle No. 67 on Reader Service Card, page 155, for more information.

Exhaust Gas Thermometer

Mfr.: Avien-Knickerbocker, Inc.
Weight: 3.5 lbs.

Includes an indicator, amplifier, and Chromel-Alumel AN thermocouple to measure and indicate exhaust gas temperatures. Range of 0-1000 degrees C with accuracy ± ½% and accuracy independent of ambient temperatures over a range—55°C to 70° C. Operates on 115-volt 400-cps at 0.28 amps.

Circle No. 32 on Reader Service Card, page 155, for more information.

INSTRUMENTS

Reference Gyro

Model: 29
Mfr.: Summers Gyroscope Co.
Weight: 3½ lbs.
Size: L-3¾", W-3-7/16", H-4¾"

Operates on 26.5 volts d-c at 0.5 amps. Used in telemetering operations for drone and missile tests, the model 29 features ¼ degree per minute drift rate. Will withstand shock of 30g's. Features remote caging and uncaging device.

Circle No. 97 on Reader Service Card, page 155, for more information.

Oscillograph

Model: 5-118
Mfr.: Consolidated Engineering Co.
Weight: 11.5 lbs.
Size: L-8", W-5", H-5"

A recording oscillograph for unattended operations under extreme environmental conditions such as airborne use in missile testing. Operates from 26-volt d-c power and is available with either 9 or 14 channels. Record speeds of 1", 2", or 3" per second are fixed at factory.

Circle No. 39 on Reader Service Card, page 155, for more information.

Magnetic Pickup

Model: 3015
Mfr.: Electro Products Laboratories
Weight: 1/3 oz.
Size: L-1-9/32", W-⅜" hex

A miniature magnetic pickup used for turbine speed indication is a rate of change device with output voltage proportional to speed. Applications include use for electrically indicating rate of speed, vibration, angular or linear motion.

Circle No. 12 on Reader Service Card, page 155, for more information.

Safety Destructors

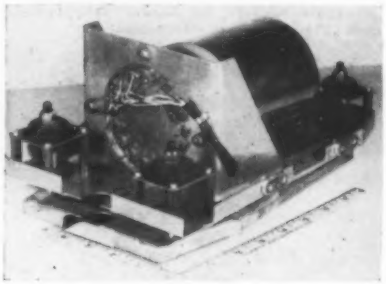
Mfr.: Beckman and Whitley, Inc.

Devices designed to destroy identity of a guided missile or to spoil aerodynamic stability to confine a flight to a missile range. Firing system can be actuated by acceleration, by radio, or by physical means before flight.

Circle No. 64 on Reader Service Card, page 155, for more information.

Vertical Gyro

Model: G-110
Mfr.: Schwien Engineering Co.
Weight: 4.5 lbs.
Size: L-5⅝", Dia.-4 1/16"

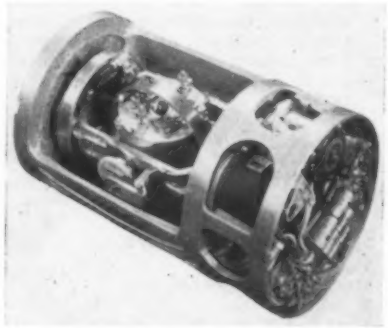


An all stainless steel yet lightweight gyro for missile control systems operates from 28-volt d-c, or 26, or 115-volt 400-cycle single- or three-phase input. Uses new potentiometer techniques.

Circle No. 20 on Reader Service Card, page 155, for more information.

Directional Gyro

Model: 976-L
Mfr.: Lear, Inc.—Grand Rapids Div.
Weight: 5.1 lbs.
Size: L-6", Dia.-4⅝"



A stabilized directional reference gyro for flight control and fire control tie-in operates from 1, 5, 20, 30, 32, 40, or 55-volt, 400-cycle single-phase input current. Features an integral leveling system, slaving signal receiver, remote compass transmitter, and yaw synchronizing system.

Circle No. 68 on Reader Service Card, page 155, for more information.

Free Gyro

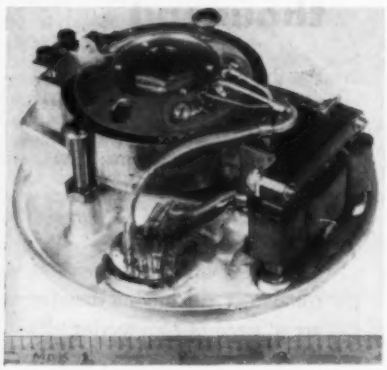
Model: 221A
Mfr.: Summers Gyroscope Co.
Weight: 5 lbs. 12 oz.
Size: Dia. 3⅝", L-5-7/32"

Operates on 26-v, 400-cps for caging with 115 v, 400-cps for the motor and 30-volt d-c for uncaging. Accelerates to operational speed in 10 seconds. Caging (under 60 seconds from any position) independent of gyro motor. Drift less than one degree per minute. Withstands 60g launching acceleration along output axis. Critical frequency is 270-290 cps.

Circle No. 113 on Reader Service Card, page 155, for more information.

Rate Gyro

Model: 977-J
Mfr.: Lear, Inc.—Grand Rapids Div.
Weight: 1¼ lbs.
Size: L-2-1/32", Dia.-4-3/16"

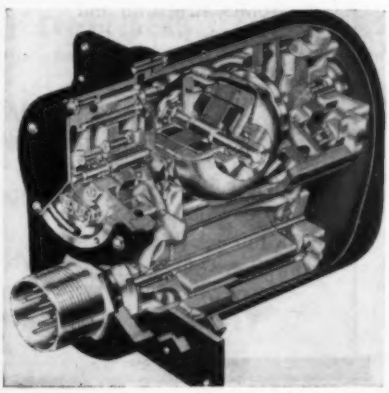


A hermetically sealed yaw stabilization sensing element operates from 115-volt 3-phase 400-cycle or 45-volt, single-phase 400-cycle current. Output is a 400-cycle single-phase sinusoidal signal proportional to displacement and phase related to direction. Senses angular velocity from .05° per second to 12° per second.

Circle No. 99 on Reader Service Card, page 155, for more information.

PAR Gyro

Model: 245
Mfr.: Summers Gyroscope Co.
Weight: 3 lbs.
Size: L-5⅛", W-3", H-4-9/16"



Operates on 400-cycle a-c at 200 ma with output of 35 mv/degree, 7 mv/-degree/sec. Used in all-weather autopilot. Two microsyns used as signal pick-offs. One has output proportional to position plus rate, the other proportional to position only.

Circle No. 53 on Reader Service Card, page 155, for more information.

Accelerometer

Model: DDL
Mfr.: Genisco, Inc.
Weight: 40 oz.
Size: L-3¼", W-2¼", H-3⅛"

Operates over range of ± 1g to ± 3g with linear potentiometer output. Used primarily in control systems requiring high resolution at low accelerations. Output linear within ± 1%. Features both permanent magnet and oil damping.

Circle No. 11 on Reader Service Card, page 155, for more information.

Rate Gyro

Model: R-100
Mfr.: Schwien Engineering Co.
Weight: 2 lbs.
Size: Dia.-2-9/16", L-4"

Operates on 28-volt d.c., or 26-volt or 115-volt, single- or three-phase, 400-cycle. Potentiometer or microsyn output. Gimbals and frames made from inconel steel. Free from effects due to differential expansion of components.

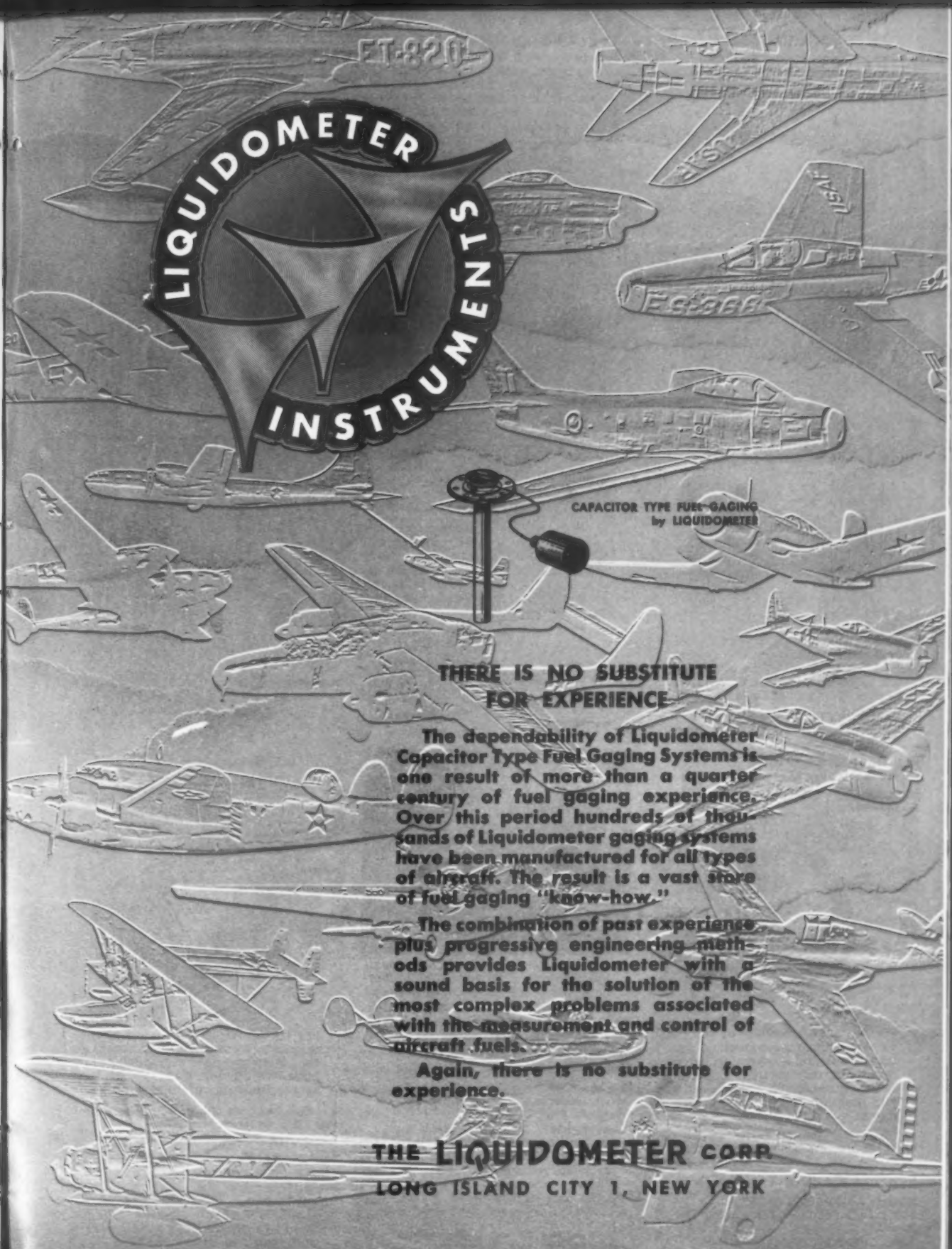
Circle No. 117 on Reader Service Card, page 155, for more information.

Synchronous Camera

Model: IV-C
Mfr.: Flight Research, Inc.
Weight: 11 lbs.
Size: L-8-7/16", W-7", H-5-11/16"

For flight testing and missile tracking operations, this 35mm synchronous motion picture camera has a 100-ft. daylight spool with auxiliary adapter for 400-ft. or 1000-ft. magazine. Operates from 28-volt d-c and 115-volt 400-cycle current.

Circle No. 98 on Reader Service Card, page 155, for more information.



CAPACITOR TYPE FUEL-GAGING
by LIQUIDOMETER

THERE IS NO SUBSTITUTE FOR EXPERIENCE

The dependability of Liquidometer Capacitor Type Fuel Gaging Systems is one result of more than a quarter century of fuel gaging experience. Over this period hundreds of thousands of Liquidometer gaging systems have been manufactured for all types of aircraft. The result is a vast store of fuel gaging "know-how."

The combination of past experience plus progressive engineering methods provides Liquidometer with a sound basis for the solution of the most complex problems associated with the measurement and control of aircraft fuels.

Again, there is no substitute for experience.

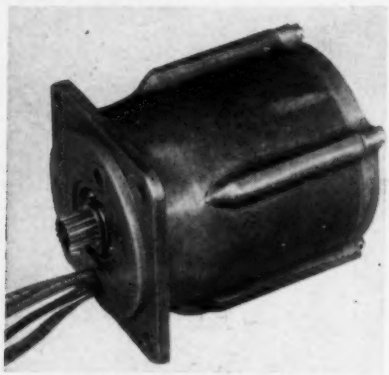
THE LIQUIDOMETER CORP.
LONG ISLAND CITY 1, NEW YORK

CAPACITOR TYPE FUEL QUANTITY GAGES • LIQUIDENSITOMETERS TO PROVIDE TRUE FUEL WEIGHT INDICATION • FLOAT ACTUATED GAGES MINIATURE COAXIAL CABLE CONNECTORS • POSITION TRANSMITTERS • POSITION INDICATORS • FLOAT SWITCHES • LIQUID LEVEL WARNING SWITCHES • LIQUID LEVEL CONTROLS • CENTER OF GRAVITY CONTROL SYSTEMS AND OTHER INSTRUMENTATION

ELECTRONICS

Velocity Generator

Model: 15G-06B-2
Mfr.: Lear, Inc.-Grand Rapids Div.
Weight: 8 oz.
Size: L-2", Dia.-1½"



A velocity feed-back for control circuit damping operates from 115-volt, 400-cycle, single-phase with output of 0.36 volts at 1000 rpm. Uses shaft pinion-type drive.

Circle No. 1 on Reader Service Card, page 155, for more information.

Sequence Selector

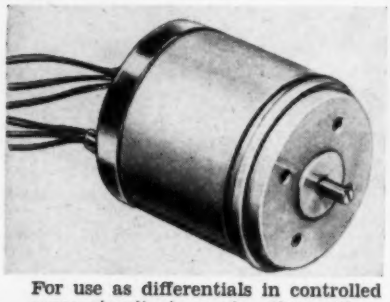
Model: Baker
Mfr.: Guardian Electric Mfg. Co.
Weight: 3.5 lbs.
Size: L-7½", W-3-9/16", H-3½"

Meets MIL-QS 5923B and MIL-E 5700 for missile sequence selection. Handles 24 circuits. Travel: Min. .005 sec., Max. .010 sec. speed of impulses. Designed for 28 volts d-c.

Circle No. 58 on Reader Service Card, page 155, for more information.

Autosyn Differential

Model: AY-230S-3
Mfr.: Eclipse-Pioneer
Weight: 5 oz.
Size: Dia.-1.431", L-1.631"



For use as differentials in controlled servo circuits in conjunction with a transmitter and a control transformer to permit introduction of an additional variable. Rotor is mechanically positioned or driven by a prime mover.

Circle No. 107 on Reader Service Card, page 155, for more information.

Synchro Control Transmitter

Model: 23CX-01B-1
Mfr.: Lear, Inc.-Grand Rapids Div.
Weight: ¼ lb.
Size: Dia.-2¼", L-.540"

Synchro control transmitter for data transmission systems featuring lightweight, pancake construction. 360-degree sensing. Operates on 115-volt, single-phase, 400-cycle input with output matching "Autosyn" type synchro control transformers.

Circle No. 22 on Reader Service Card, page 155, for more information.

Rate Gyro Transmitter

Model: 15814-1-A
Mfr.: Eclipse-Pioneer
Weight: 13.5 oz.
Size: Dia.-2", L-2"

Provides electrical signal proportional to rate of turn. Has same gyro rotor moment as larger gyros. Gyro motor operates on 26-volts, 400-cps, 3-phase at 22,000 rpm rated speed. Vibration operating range 5g from 20 to 300 cps.

Circle No. 65 on Reader Service Card, page 155, for more information.

Phase Comparator

Model: 2
Mfr.: Sanders Associates
Weight: 2 oz.
Size: Dia.-1", H-3"

Dynamic range of 46 decibels, maximum output ± 50 volts d-c, 2 channels, frequency range of 0-5000 cps. Unit is hermetically sealed.

Circle No. 119 on Reader Service Card, page 155, for more information.

Relay

Model: 2005
Mfr.: Guardian Electric Mfg. Co.
Weight: 4 oz.
Size: L-1.187", W-1.187", H-2¼"

A continuous duty relay rated for 30 volt maximum operation has a pick-up voltage of 18 volts and nominal voltage of 24-28 volts. Coil resistance is 195 ohms ± 10% and contacts are rated at 5 amps d-c.

Circle No. 77 on Reader Service Card, page 155, for more information.

Electrolytic Pickoff

Model: 1250A
Mfr.: Lear, Inc.-Grand Rapids Div.
Weight: 1 oz.
Size: L-⅜", Dia.-1-3/16"

A gravity-sensing pickoff used as a series circuit element with resistance variation proportional to deviation from vertical. Rated at 15 ma continuous series current and 50 ma intermittent. Input requirements are 55-volt, 400-cycle, single-phase.

Circle No. 36 on Reader Service Card, page 155, for more information.

Telemetering Switch

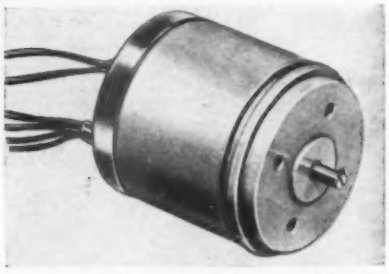
Model: TM 51 Series
Mfr.: Mycalex Electronics Co.

Range of one to 20 rps, 90 channels Mycalex 410 commutator designed to withstand thermal shock and maintain precision dimensional relationships. Used in Raymond Rosen, North American Aviation, and J. P. Seeburg, telemetering systems.

Circle No. 42 on Reader Service Card, page 155, for more information.

Autosyn Resolver

Model: AY-240S-5
Mfr.: Eclipse-Pioneer
Weight: 5 oz.
Size: Dia.-1.431, L-1.631



For use as resolvers in servo circuits to rotate rectangular coordinates or for interchanging rectangular and polar coordinates. Can also be used as precision phase shifting units.

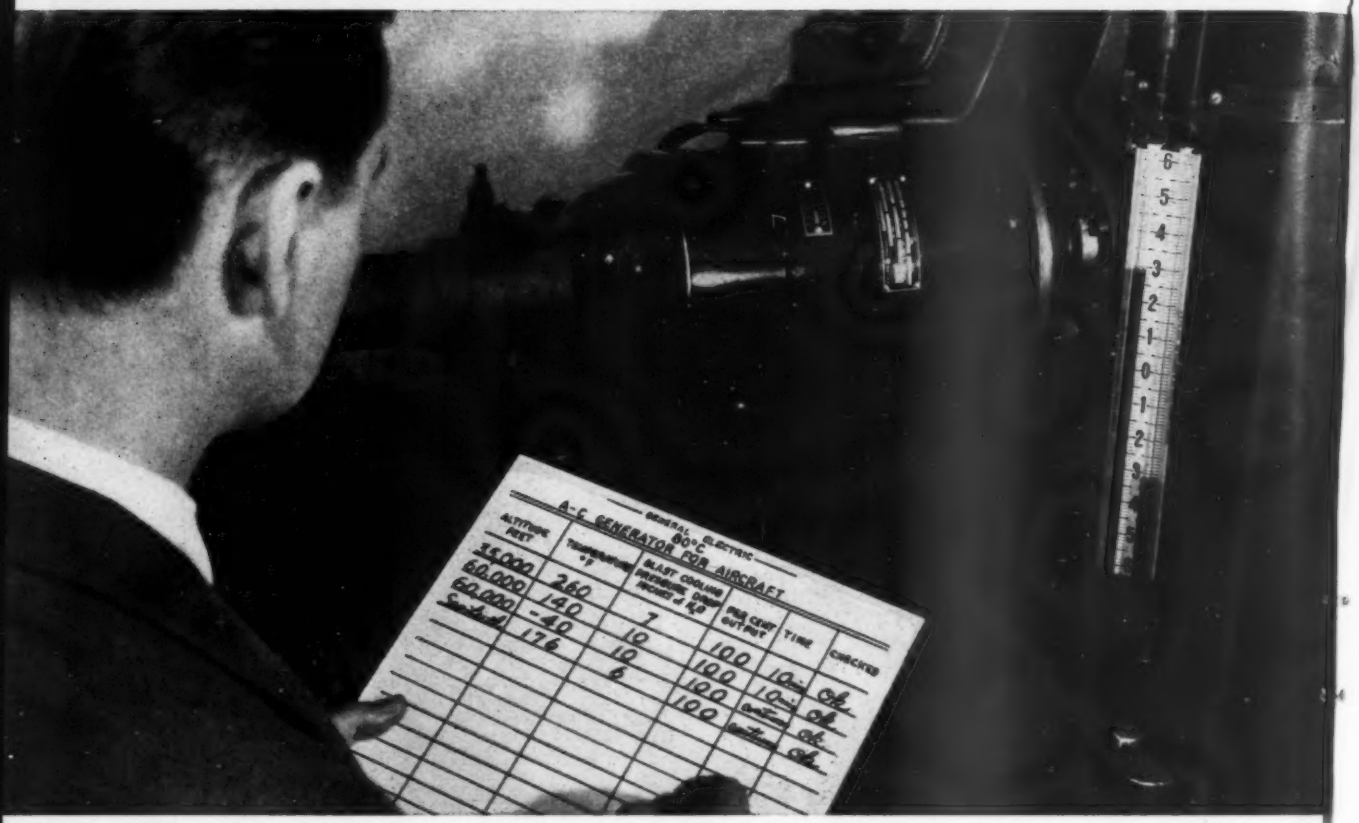
Circle No. 108 on Reader Service Card, page 155, for more information.

Tube Tester

Model: REL-03B
Mfr.: Rheem Mfr. Co.
Size: Six-foot dual console rack

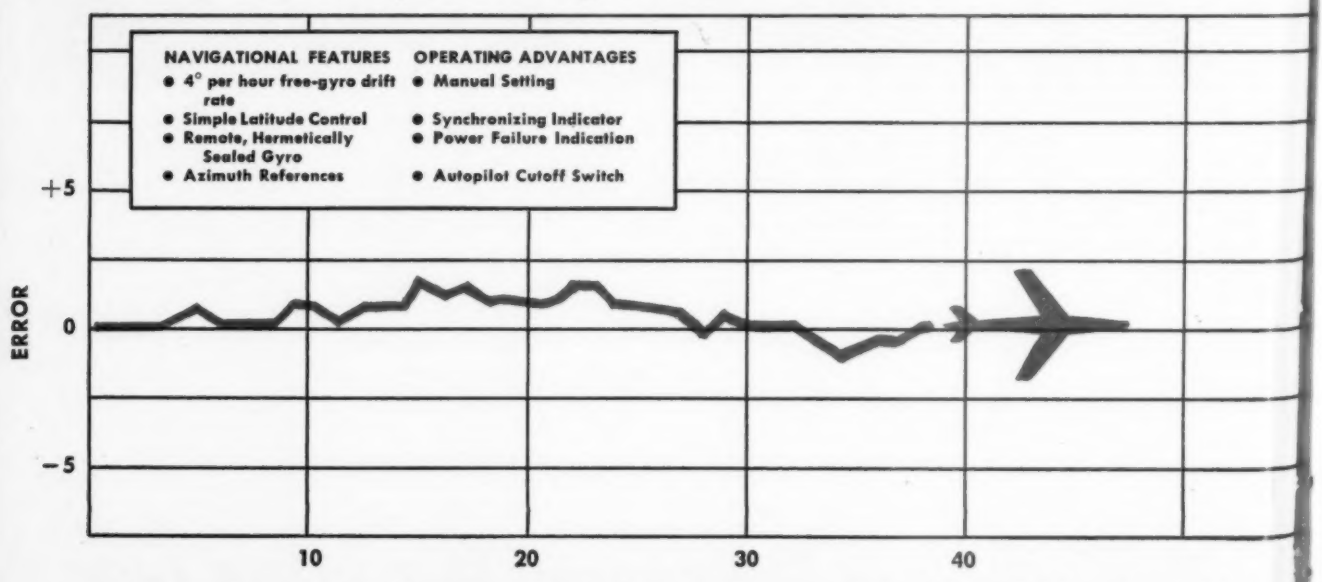
Operates on 110-volt, 60-cycle, a.c. Used to evaluate electron tubes while undergoing enviromental tests. Tests

New G-E automatic a-c electrical system



New G-E high-efficiency a-c generator has no harmonic over 1%, and offers full load recovery in about 1/10 sec. Available ratings: 10 to 60 kva, 380/420 cycles, 5700/6400 rpm, 120/208 volts.

New G-E compass system reduces aircraft



Low drift of gyro system proved in laboratory and flight tests. The above drift curve was obtained during a roll-pitch-yaw test on a G-E gyro unit. This test, conducted by an outside equipment laboratory, showed that at no time did the drift rate exceed 4° per hour—66-80% reduction over previous systems. Flight test conducted later upheld the laboratory findings.

delivers load at 260F

A new, fully automatic parallel a-c electrical system which eliminates normal manual switching, and delivers rated load at higher ambient temperatures than ever before possible, has been developed for jet aircraft by General Electric.

Designed for supersonic dash

Designed specifically to meet the high ram-air temperatures of supersonic dash, this new G-E generator system provides the best voltage regulation and most advanced system protection available in production today. The automatic system delivers full load at:

- Sea level with 176 F cooling air at 6-inch water drop (continuous).
- 60,000 feet with −40 F cooling air at 10-inch water drop (continuous).
- 60,000 feet with 140 F cooling air at 10-inch water drop (ten minutes).
- 35,000 feet with 260 F cooling air at 7-inch water drop (ten minutes).

Speeds take-off, spares pilot

The first completely automatic a-c system ever produced, the new G-E equipment begins operating as soon as the pilot starts an engine. The system contains only two toggle switches, which can remain "on" at all times unless a fault develops. This eliminates a series of pilot functions, and sharply reduces time required to become airborne after the pilot climbs into the cockpit. System control and protection is fully automatic.

Single source for complete systems

General Electric offers a single source for complete a-c or d-c power generation systems for any aircraft. For more information, contact your nearest G-E aviation specialist, or write Section 210-86, General Electric Company, Schenectady 5, N. Y.

Major components of the new G-E system in addition to the generator are:

1. **New static regulator (left)—designed to last the life of the aircraft though regulator is only 390 cubic inches and weighs only 13 lbs.**
2. **Control and protective equipment (right) automatically locates and isolates any faulty generator. Control panel weighs only 8½ lbs. for a single-generator system and only 10¼ lbs. for parallel generator systems.**

drift rate 66 — 80%

A new compass-controlled directional gyro system which offers a free-gyro drift rate of only 4° per hour—66 to 80 per cent more efficient than present systems—has been developed by General Electric for helicopters and fighter aircraft.

Weighs only 17.5 lbs.

Compact and lightweight (approximately 17.5 lbs.), the MA-1 compass system is designed to meet the requirements of any synchronous course-indicator, and will operate from all compass transmitters built to Air Force specification AF-27635.

Accurate, stabilized heading information

The MA-1 system offers accurate, stabilized heading information continuously through 360° in azimuth when slaved to the earth's magnetic field through a modern remotely mounted compass.

Featuring a normal slaving rate of approximately 2° per minute during compass-controlled operation, the MA-1 system also provides for controlled latitude-drift compensation.

Aircraft systems development

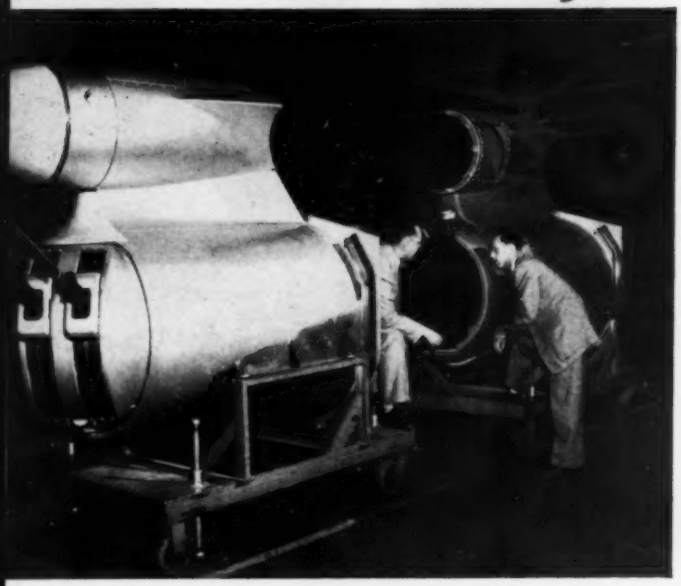
For additional information regarding reliable aircraft systems development, contact your G-E aviation specialist or write Section 210-86A, General Electric Co., Schenectady 5, N. Y.

1. **Amplifier provides a junction box for various components and power source as well as containing leveling, slaving and servo amplifiers, servo unit with detector, follow-up and output synchros.**
2. **Controller is used in conjunction with the radio-magnetic indicator for setting directional heading and latitude control and for general operation of the system.**
3. **Directional gyro, heart of the G-E system, is a remote, low-drift hermetically sealed gyro used to obtain a stabilized azimuth heading.**

Progress Is Our Most Important Product

GENERAL ELECTRIC

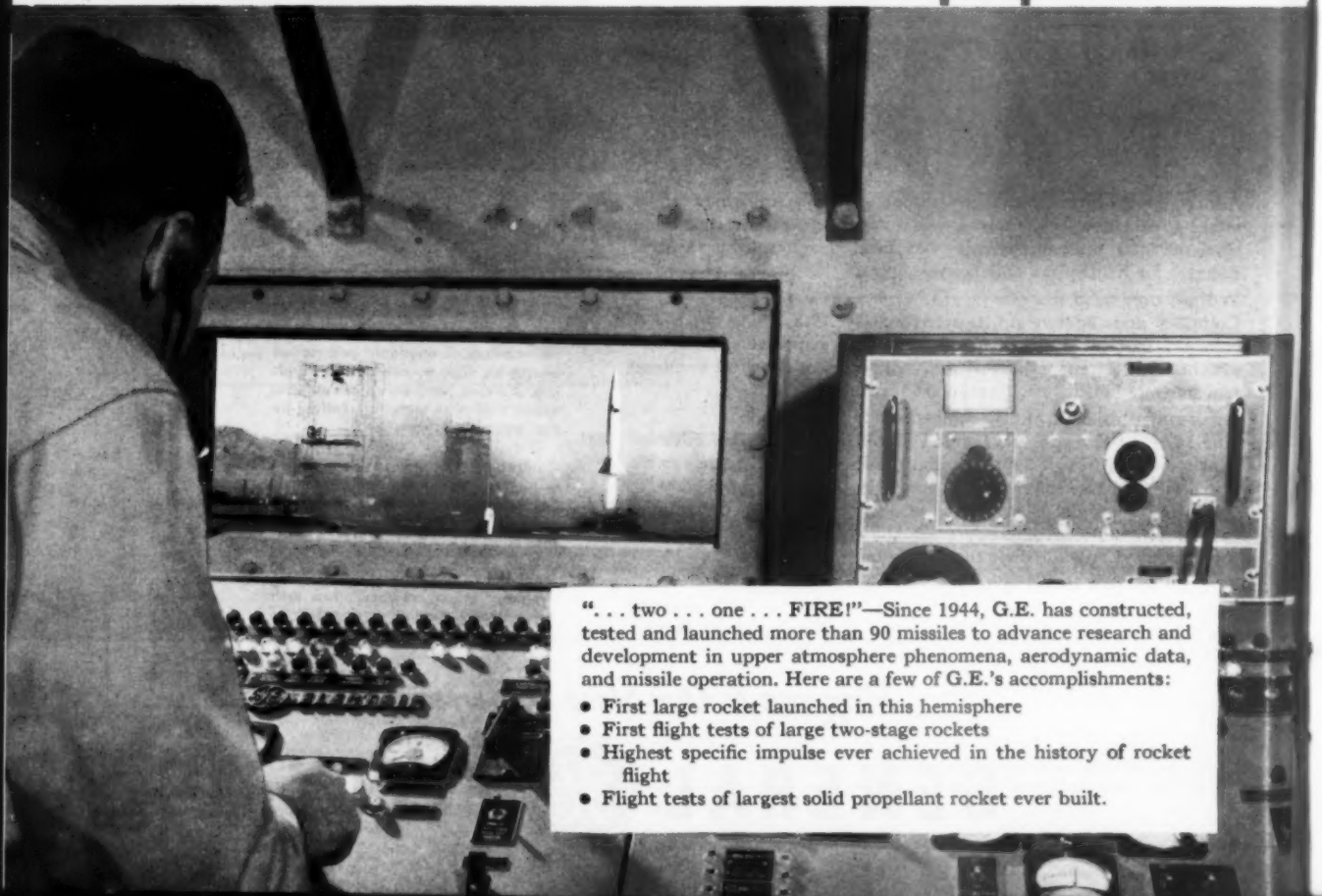
New G-E armament system gives jet bombers



This new 20 mm system is a result of G.E.'s "integrated system" approach whereby a group of engineers is responsible both for development and modification of a system for greatest efficiency and ease of maintenance.

Cold and hot chambers with temperatures ranging from —90 F to 170 F are only two of the elaborate tests G-E armaments systems undergo to help insure maximum flight efficiency.

New land-sea-air uses for rocket propulsion



"... two ... one ... FIRE!"—Since 1944, G.E. has constructed, tested and launched more than 90 missiles to advance research and development in upper atmosphere phenomena, aerodynamic data, and missile operation. Here are a few of G.E.'s accomplishments:

- First large rocket launched in this hemisphere
- First flight tests of large two-stage rockets
- Highest specific impulse ever achieved in the history of rocket flight
- Flight tests of largest solid propellant rocket ever built.

automatic defense

A remote-controlled 20 mm armament system, capable of finding, tracking and hitting hostile aircraft even in the night or fog, has been developed by General Electric for high-speed jet bombers.

"Packaged" protection for B-47E and RB-47E

Under security wraps for three years, the G-E fire control system provides more reliable, automatic protection for the Boeing B-47E and RB-47E jet bombers. Compact, the 20 mm system is delivered packaged, tested, and ready to be installed as a complete tail section.

Automatic warning, tracking, correcting

The system performs the following functions:

- Provides automatic radar warning of approaching aircraft
- Automatically tracks and positions guns on selected target
- Continuously corrects for windage, ballistics, and lead errors by means of an electric computing network
- Fires guns electrically when target is in range.

System Engineering

Bomber survival is increased as a result of this integrated, effective, compact system. Competent system engineering is one reason why almost every U.S. operational heavy and medium bomber today is equipped with General Electric armament systems. General Electric Company, Schenectady 5, N. Y.

Remote-controlled G-E armament system gives the Boeing B-47E and RB-47E jet bombers a heavyweight punch to the rear. Guided by radar, the 20 mm system can track and hit unseen targets.

under study by G.E.

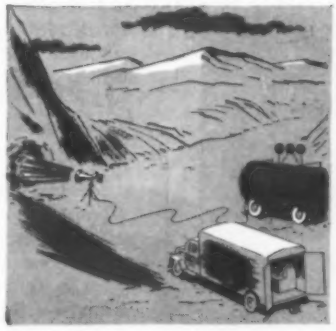
Ten years ago, rocket propulsion had but one use . . . to launch missiles. But today, rocket power as a source of high pressure, high speed, high temperature gases and power can be used in such applications as torpedo propulsion, catapult energizers, high-speed flight, thrust augmentation, rocket booster and sustaining power, high-speed research sleds, glider take-off and landing, supersonic wind tunnels, mining, plus many additional latent military and industrial uses which will be brought out by research and development.

Experience, manpower and facilities make it possible for G.E. to design and develop rocket motors or rocket propulsion systems for use on land, sea or in the air.

The amazing growth of rocket propulsion offers a challenge to the ingenuity and imagination of American industry. This challenge—to apply the tremendous power of rocket propulsion to ever-newer applications—can be met only through continuous research and development. To this end, General Electric offers its successful experience, its trained manpower, and its extensive facilities. General Electric Company, Schenectady 5, N. Y. 210-86B

TORPEDO PROPULSION

THRUST AUGMENTATION



MINING

SUPERSONIC WIND TUNN

Progress Is Our Most Important Product

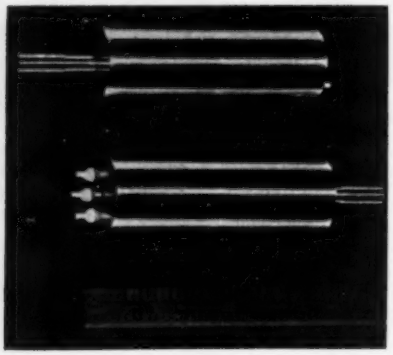
GENERAL ELECTRIC

for all MIL-E-1B electron tube specs. Meters provided for simultaneous observation of all pertinent tube parameters. Modular design for simplicity.

Circle No. 124 on Reader Service Card, page 155, for more information.

Linear Transducer

Mfr.: Crescent Engineering & Research Co.
Size: Dia.-1", L-3" up to 65"

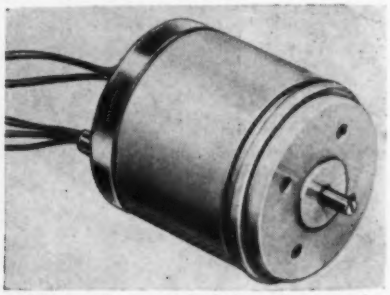


For measuring linear movement, relative displacement, position, and vibration. This transducer requires no cooling when operated below 1300°F. Features include range from 1" to 32", sensitivity of 5 volts-per-inch and linearities to 1% of linear range.

Circle No. 109 on Reader Service Card, page 155, for more information.

Control Transformer

Model: AY-200S-3
Mfr.: Eclipse-Pioneer
Weight: 5 oz.
Size: Dia.-1.431", L-1.631"



Designed as control transformers in controlled (servo) circuits. Three types provided with shaft extension dimensions major difference. Operates on 26-volt, 400-cycle, single-phase current.

Circle No. 6 on Reader Service Card, page 155, for more information.

Autosyn Receiver

Model: AY-200S-2
Mfr.: Eclipse-Pioneer
Weight: 5 oz.
Size: L-1.631", Dia.-1.431"

Miniature precision Autosyns for use as receivers in servomechanism and computer equipment. Operates on 26-volt, 400-cycle, single-phase current and input of 0.45 watts.

Circle No. 52 on Reader Service Card, page 155, for more information.

Autosyn Transmitter

Model: AY200S-1
Mfr.: Eclipse-Pioneer
Weight: 5 oz.
Size: L-1.631", Dia.-1.431"

Miniature precision autosyn synchros for missile servomechanisms and computing equipment are proposed for applications where more than one receiver or control transformer will be used with the transmitter. Operates from 26-volt, 400-cycle, single-phase current.

Circle No. 30 on Reader Service Card, page 155, for more information.

Free Gyro

Model: 14108-1-A
Mfr.: Eclipse-Pioneer
Weight: 4.2 lbs.
Size: L-5 5/16", Dia.-3⅞"

A free gyro roll axis transmitter occupying only 63 cu. in. space has a rated operating life of 500 hours.

Circle No. 122 on Reader Service Card, page 155, for more information.

Pacitron*

measures and manages fuel for guided missiles

Now an important new achievement—the design and installation of a fuel gage system for an advanced type of guided missile—has been added by Simmonds Aerocessories, Inc. to its long record of leadership in the development of aircraft capacitance fuel gage systems.

In this installation, the Pacitron system makes provision for telemetering vital information to control points, in addition to the accurate and reliable measurement of fuel available.

Under the stress and pressure of sub-sonic and super-sonic speeds, Pacitron once again successfully demonstrates the high performance features that have made Simmonds first in electronic fuel gaging.

*Pacitron is a U. S. trademark

SIMMONDS AEROCESSORIES, Inc.

General Offices: TARRYTOWN, N. Y. • Branch Offices: GLENDALE, CALIF. • DALLAS, TEXAS • DAYTON, OHIO
Sole Canadian Licensee: SIMMONDS AEROCESSORIES OF CANADA LIMITED—MONTREAL

Pacitron Measures Hard-to-Measure Liquids

The uniquely designed sensing element (tank unit) of the Pacitron system is particularly adaptable to the measurement of hard-to-measure liquids. In addition to aviation gas, kerosene and the JP fuels, Pacitron has successfully gaged engine oil, water methanol, nitric acid and other conductive fluids. Compensation for deviation in types of fuels also can be provided through a monitoring device.

The Extra Engineer—When Pacitron fuel gage system provides fuel management as well as fuel measurement.

Gyro motor supply is 26-volt, 400-cycle, 3-phase, and motor speed 22000 rpm. Unit operation becomes stabilized within two minutes of power application and drift rate will not exceed 1° per minute after allowance for earth's rotation.

Circle No. 57 on Reader Service Card, page 155, for more information.

Power Amplifier

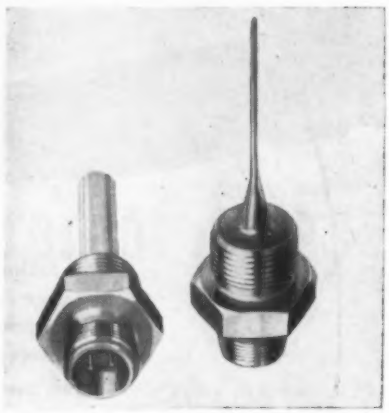
Model: REL-06
Mfr.: Rheem Mfg. Co.
Weight: 2 lbs.-4 oz.
Size: L-5", W-4", H-4⅝"

Used to amplify power output of telemetering transmitters. Input requirements are 1.4 to 2.3 watts, output 18 watts over frequency range of 215 to 235 megocycles.

Circle No. 106 on Reader Service Card, page 155, for more information.

Temperature Detector

Model: 221
Mfr.: Thomas A. Edison, Inc.
Weight: 3.25 oz.
Size: Dia.-7/16", L-4"



Used to measure temperature of hydrogen peroxide in production model rocket engines. Response rate of 0.8 second or better. Hermetically sealed and corrosion resistant. Measure to 300° C maximum ambient temperature.

Circle No. 2 on Reader Service Card, page 155, for more information.

Radar Transponder Beacon

Model: RBX
Mfr.: General Communication Co.
Weight: 2 lbs.
Size: Dia.-2½", H-6½"

Used to facilitate radar tracking of missile in upper atmosphere. Will operate 30 minutes with companion

FOR SALE OR LEASE

AIRCRAFT ENGINE OVERHAUL SHOP

LARGEST IN THE EAST

Production Capacity—100 engines a month
CAN HANDLE MAJOR OVERHAUL on engines R-985 through R-4360
FOUR modern concrete engine test cells equipped for radial and horizontal engines

Complete military and CAA-approved Class 1 and 2 facility for aircraft engine and accessory overhaul available for immediate sale or lease. Located 30 minutes from New York City on Linden, New Jersey Airport. Outstanding production record for the Armed Services, air carriers and corporate operators throughout the world.

Pacific Airmotive Corporation is consolidating its engine overhaul facilities in our recently expanded Burbank, California plant. For this reason, we are offering to sell or lease our Linden plant—completely equipped.

PAC can furnish technical and sales assistance required to carry on present operations or to reestablish the operation at another domestic or foreign location. Write, call or cable today for complete information on this fine engine overhaul facility. Attention Thomas Wolfe, President.

25 YEARS SERVICE TO AVIATION
8 BRANCHES

PAC

Pacific Airmotive Corporation

2940 NORTH HOLLYWOOD WAY
Burbank, California

Phone: Victory 9-3481
Cable: PACAIR

power supply of same weight and dimensions. Operates on 6.3 volts input at 3 amps and has 50 watt peak output. Frequency range: 2850 to 2900 mcs.

Circle No. 5 on Reader Service Card, page 155, for more information.

Electronic Chopper

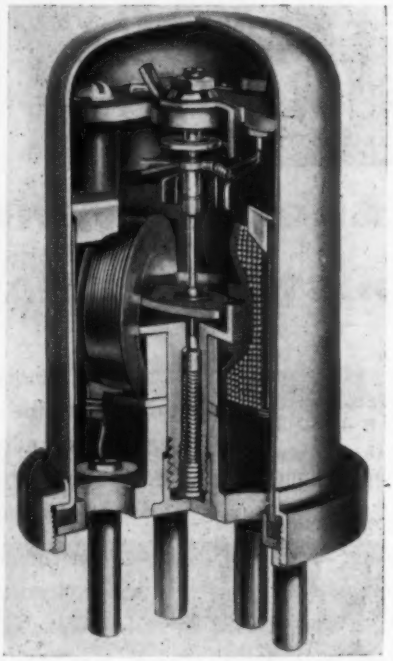
Model: 207
Mfr.: Avion Instrument Corp.
Weight: 1.6 oz.
Size: L-⅞", W-⅞", H-2"

Non-mechanical chopper operating over a frequency range of 20 to 1000 cycles per second features exceptionally stable and long-life operation.

Circle No. 31 on Reader Service Card, page 155, for more information.

Magnetic Relay

Model: 220
Mfr.: Thomas A. Edison, Inc.
Weight: .15 lbs.
Size: Dia.-1.113", H-1 29/32"



Rated at 28 volts d-c, 1/3 amp. SPST or SPDT. Operates directly from R.F. signals without electronic amplification. Features automatic resetting and high sensitivity. Contacts are not magnetic.

Circle No. 62 on Reader Service Card, page 155, for more information.

Pressure Transducer

Model: GPT
Mfr.: Genisco, Inc.
Weight: 11 oz.
Size: L-2½", W-2", H-2"

Vacuum sealed for resistance to environmental conditions, the GPT has a capacity of 5000 and 10,000 ohm standard potentiometer; 7 milliamperes continuous duty. Input range 0-80 psi absolute, fluid or gas with linear potentiometer output. One or two circuits. Used in control systems responsive to ram and static air pressures.

Ignition Exciter

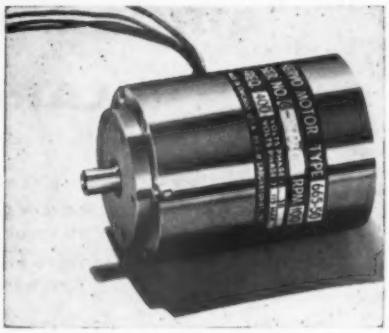
Model: 7150-1
Mfr.: General Laboratory Associates, Inc.

A low-voltage input, high-KV output ignition unit used in the Martin B-61 Matador. Design is comparable to piloted plane jet ignition equipment but lighter and less costly.

Circle No. 80 on Reader Service Card, page 155, for more information.

Geared Servo Motor

Model: 50
Mfr.: G-M Laboratories, Inc.
Weight: 17.5 oz.
Size: Dia.-1.750", L-2¼"

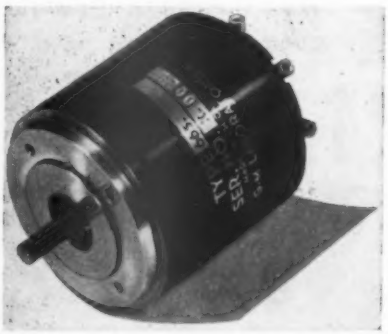


Operates on 115 volts, 400 cycles. Features 55 to 1 gear ratio.

Circle No. 94 on Reader Service Card, page 155, for more information.

Servo Motor

Model: 53
Mfr.: G-M Laboratories, Inc.
Weight: 12.2 oz.
Size: Dia.-1.750", L-2"



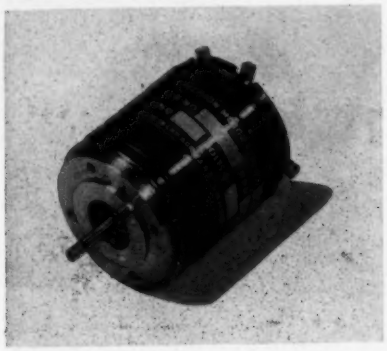
Operates on 115 volts, 400 cycles.

Circle No. 105 on Reader Service Card, page 155, for more information.

Plants at Lynwood, Pasadena, Belmont, San Francisco (Calif.) Seattle and Houston • Representatives in principal cities

Servo Motor

Model: 52
Mfr.: G-M Laboratories, Inc.
Weight: 7.3 oz.
Size: Dia.-1.437", L-1⅝"



Operates on 115 volts, 400 cycles.

Circle No. 3 on Reader Service Card, page 155, for more information.

Synchroverter Chopper

Model: D-9
Mfr.: The Bristol Co., Aircraft Products Div.
Weight: 1.7 oz.
Size: H-2", Dia.-27/32"

Hermetically sealed chopper for guided missile control, radar, or analog computer applications. Fits a 7-pin tube socket and miniature tube shield.

Circle No. 24 on Reader Service Card, page 155, for more information.

Roll Corrector

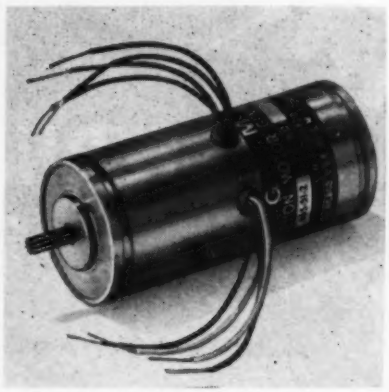
Model: D-15560
Mfr.: Ketay Instrument Co., Inc.
Weight: 1 lb.
Size: L-2-3/16", W-1¼", H-1¼"

Operates from either 26-volt, 400-cycle, .25-amp. a-c or 30-volt, 10-ma d-c, input with output of 11.8 volts over a frequency range of 380-420 cycles per second.

Circle No. 59 on Reader Service Card, page 155, for more information.

Servo Motor-Generator

Model: 51
Mfr.: G-M Laboratories, Inc.
Weight: 4 oz.
Size: Dia.-.980", L-2-5/32"



Operates on 26 volts, 400 cycles.

Circle No. 73 on Reader Service Card, page 155, for more information.

Heating Elements

Models: Many
Mfr.: Cox and Co., Inc.

Company produces Thermopatch, Thermowire, and Thermosheet heating elements used in such missile applications as battery packs, gyros, intervalometers, electrolytic capacitors, etc. Used in more than 300 military applications. Thickness: .030"

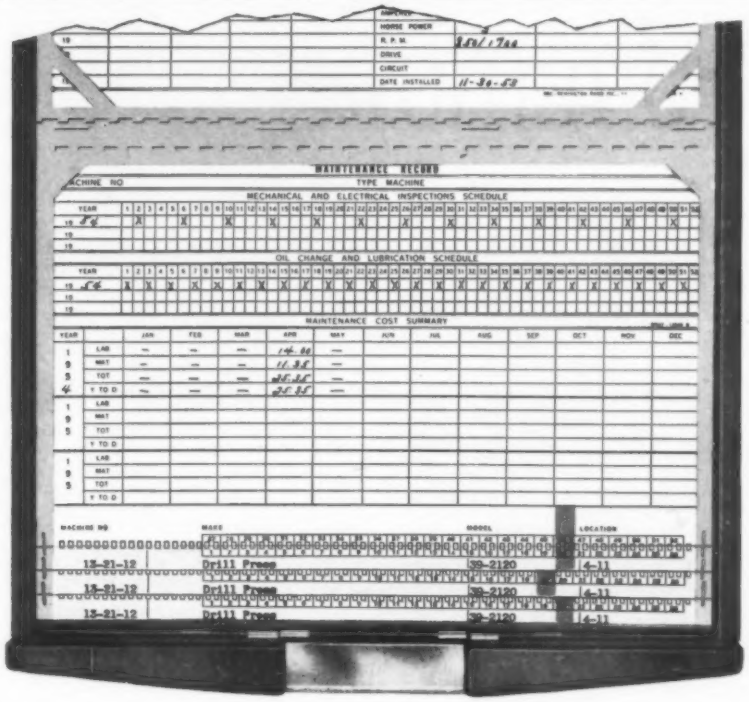
Circle No. 93 on Reader Service Card, page 155, for more information.

Feedback Control Box

Model: 7841
Mfr.: Teleflex Inc.
Weight: About 2 lbs.
Size: L-3½", W-3½", H-2"

Employs a cable with helical "teeth" which engage a gear wheel for rotary motion. Incorporates spring-loaded feature for accuracy. Accurate within 1/10 of one percent in an 8-foot system with 270 degrees of bend.

Circle No. 125 on Reader Service Card, page 155, for more information.



Integrated Preventive Maintenance Program Protects Capital Investment, Cuts Down-time and Product Costs

A well-integrated Preventive Maintenance Program will include: Equipment Records, Maintenance Parts Control, Written Work Orders, Work Scheduling and Executive Reports.

A Kardex Equipment Record (partially illustrated above) gives a complete machine history, at a glance. This record includes a history of depreciation, mechanical and electrical inspections, oil change and lubrication, plus a *maintenance cost summary*, to aid management decisions on machine replacement or retirement.

Written Work Orders are essential for planning job assignments and for correct cost accounting. They alert maintenance executives to all conditions affecting work to be performed, put an end to the errors and misunderstandings that result from verbal orders.

Your *integrated* system will aid in the preparation of Executive Reports. Here, visibly-signalled Kardex records have proved to be most efficient. More details on this phase, and on the entire Maintenance Control System, are yours in booklet X1383, offered in the coupon.

Tight Maintenance Parts Control Helps Reduce Inventory Investment, Production Stoppage, Overtime

With tight control over parts and supplies, scheduled maintenance and necessary repairs are expedited; production stoppage and overtime are held to a minimum. Maintenance parts records should list available balances on hand, usage and trend of usage, vendors, date and quantity of last order. Effective control includes a numbering system to eliminate duplicate items, cut inventory investment. Kardex Visible records, with movable Graph-A-Matic signals, save time by focusing attention on items nearing reorder point. See booklet X1383.

Sched-U-Graph Controls Maintenance Force Workload for Proper Job Sequence; Minimizes Lost Man-hours

To be effective, any preventive maintenance system will *plan* the workload for each member of the maintenance crew. The ideal method of workload scheduling is the *visible* method; the ideal visible tool for the job is the Remington Rand Sched-U-Graph.

Sched-U-Graph assures handling of maintenance jobs in proper sequence, for minimum interference with production. Sched-U-Graph tells the foreman, at a glance, what job each worker is on and how long

it should take, or, if he is free for immediate assignment. Result: Increased efficiency on the part of each worker, higher output, less waste. Further details on visible scheduling with Sched-U-Graph are contained in booklet X1383. Send for your free copy today.

Sealed Thermostat

Model: S1-1A
Mfr.: Thomas A. Edison, Inc.
Weight: .05 lbs.
Size: L-2½", Dia.-.388"

A single-pole single-throw hermetically sealed thermostat used in the Nike missile to control ambient temperature of electronic components in flight control equipment. Temperature setting is adjustable with 150°C ambient capacity. Controls within ± 0.1°C of required setting.

Circle No. 4 on Reader Service Card, page 155, for more information.

Relative Wind Transducer

Mfr.: Safe Flight Instrument Corp.
Weight: 0.73 lbs.
Size: L-4.13", W-1.28", H-1.62"

Operating on 27.5-volt d-c or 115-volt, 400-cycle a-c, the transducer is used on winged missiles to provide a continuous signal proportional to $\frac{C1}{C1 \text{ max.}}$ Can also be used on regular missiles to provide either a discreet point signal at any predetermined value of "Q" or a continuous null-type signal plus or minus approximately two degrees either side of a given value of relative wind.

Circle No. 60 on Reader Service Card, page 155, for more information.

Resistor

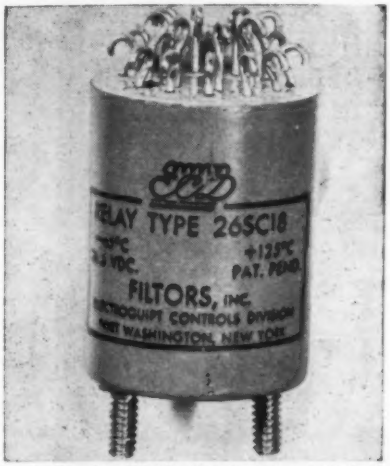
Model: 1100
Mfr.: The Daven Co.
Weight: 0.25 oz.
Size: Dia.-¼", L-¼"

Precision wire wound resistor operating at 125°C in extremely small physical space.

Circle No. 123 on Reader Service Card, page 155, for more information.

Relay

Model: 26SC18
Mfr.: Filtors, Inc.
Weight: 2.6 oz.
Size: L-1.345", Dia.-1"



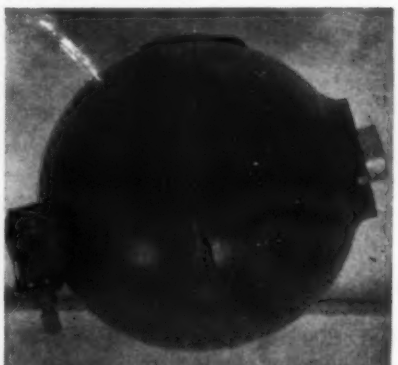
A 6-pole, double-throw relay rated at 3 amps/26.5 volts d-c or 115 volts a-c is designed for 5-500 cps vibration at 10g. Is said to withstand 50g shockload for 11 milleseconds. Input for pickup is 1.2 watts. Output torque makes or breaks 12 circuits.

Circle No. 43 on Reader Service Card, page 155, for more information.

HYDRAULICS

Spherical Accumulator

Model: X2K
Mfr.: Greer Hydraulics, Inc.
Weight: 6 lbs.
Size: L-8¾", Dia.-7"



A 2300 psi missile hydraulic accumulator of lightweight design for high shock loading. Used with Spec. MIL-O-5606 fluid, it has an oil capacity of 85 cu. in.

Circle No. 91 on Reader Service Card, page 155, for more information.

Servo Valve

Model: SA-11
Mfr.: Sanders Associates, Inc.
Weight: 2⅓ lbs. max.
Size: L-6", W-3", H-3"

A hydraulic servo valve for missile and other airborne platforms, the SA-11 is rated for 10 gpm flow and up to 12 hp output with an input of less than 2 watts. Design features include non-jamming, linearity, and no external leakage.

Circle No. 71 on Reader Service Card, page 155, for more information.

Hydraulic Accumulator

Model: 960
Mfr.: Aeroguild Inc.
Weight: 4.95 lbs.
Size: L-11-3/16", Dia.-3-21/32"

A special lightweight spherical accumulator for missile hydraulic system operation. Rated at 50 cu. in. capacity for 2100 psi system operation.

Circle No. 61 on Reader Service Card, page 155, for more information.

Pressurized Reservoir

Model: XB2
Mfr.: Greer Hydraulics Inc.
Weight 7 lbs.
Size: Dia.-19⅜", 10" at flange

An 815 cu. in. capacity hydraulic reservoir to supply low-pressure hydraulic fluid to pump in missile system. Designed for use with MIL-O-5606 fluid under maximum operating pressure of 35 psi. Rated for operation in range from —65° to +165°F.

Circle No. 104 on Reader Service Card, page 155, for more information.

Rotating components for automatic control

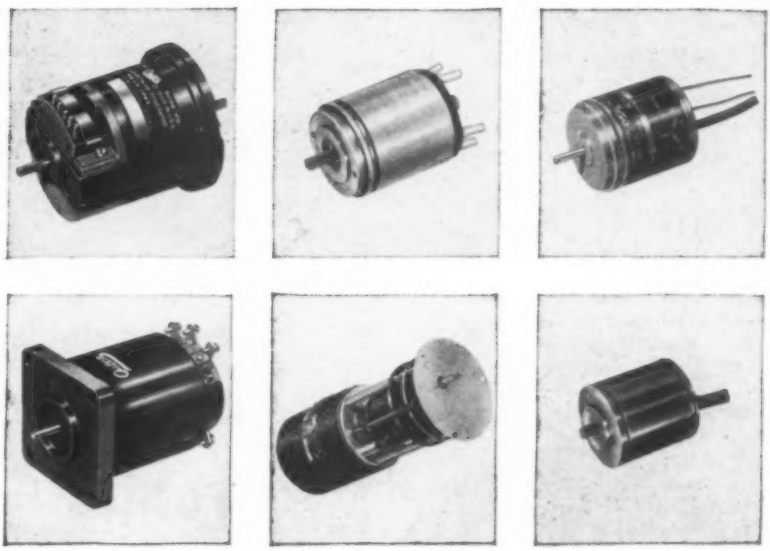
Oster®

MOTORS

SYNCHROS of all types for closed loop control systems; Synchro generators, control transformers, transmitters, differentials, receivers and resolvers, including two-speed synchros.

SERVOS to meet all specific requirements. These include servo motors providing instant response to input signal through high torque-to-inertia ratio.

DRIVE motors of 1/1500 to 1/15 HP for 60-cycle, 400-cycle single or polyphase and 50 to 1600-cycle variable frequency excitation. Also, DC fractional motors from 1/500 to 1 HP and blowers and fans for airborne applications.



Oster

GENERATORS

TACHOMETER generators—for applications in servo systems requiring accurate generation of a sinusoidal voltage, the magnitude of which is proportional to the speed of the shaft and the frequency is equal to the excitation frequency.

REFERENCE generators to induce two voltages which are displaced by 90° and the magnitude and frequency of these voltages are proportional to the speed of the rotor shaft.

John Oster MANUFACTURING CO.
AVIONIC DIVISION
RACINE, WISCONSIN

These are but a few of the OSTER precision quality products for avionics.

Insure dependability... specify Oster

Constant Speed Drive

Mfr.: Sundstrand Machine Tool Co.
Weight: 76 lbs.
Size: L-10", Dia.-10"

A hydro-mechanical constant-speed drive used in the Navajo and Snark missiles is rated for 50 hp continuous, 75 hp for five minutes, and 100 hp for five seconds. Unit operates from standard engine drive speeds and has a 6000 or 8000 rpm output.

Circle No. 44 on Reader Service Card, page 155, for more information.

Power Pack

Mfr.: Walter Kidde and Co., Inc.
Weight: 87 lbs.
Size: L-32", Dia.-11"

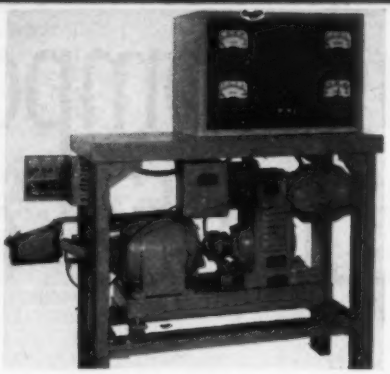
A self-contained, monopropellant-fuel, turbine-driven power pack which supplies 25 hp for 15 minutes to drive an alternator and hydraulic pump. Used in place of ram turbines or batteries in ramjet and rocket-powered missiles.

Circle No. 7 on Reader Service Card, page 155, for more information.

GROUND EQUIPMENT

Test Stand

Model: MTE
Mfr.: United Mfg. Co.
Weight: 600 lbs.
Size: L-43", W-21", H-61"

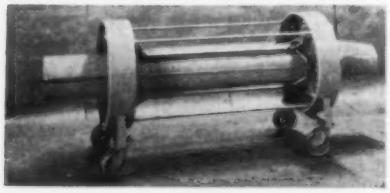


An induction generator test stand which will accelerate a generator under test to 12,000 rpm at a rate of 60,000 rpm/sec. and applies load automatically.

Circle No. 84 on Reader Service Card, page 155, for more information.

Shipping and Storage Mount

Mfr.: Mechanical Suspension Mount Co.
Size: To suit missile

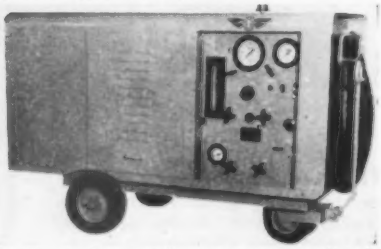


This missile shipping mount consists of concentric rings separated by coil springs arranged to handle both compression and tension. The unit is designed to fit around the missile body and is held in place by a simple lock mechanism. Casters can be attached to the mount or the enclosed assembly inserted in a shipping container. Permits six planes of freedom.

Circle No. 70 on Reader Service Card, page 155, for more information.

Hydraulic Test Stand

Model: PE3V-10V-GY2
Mfr.: Greer Hydraulics, Inc.
Size: L-83", W-38", H-53"



Used to supply pressure-regulated, temperature-controlled hydraulic power to missile control systems during tests, and for charging prior to missile launching. Uses 3000 psi pressure compensated 10 gpm pump driven by 20 hp electric motor.

Circle No. 28 on Reader Service Card, page 155, for more information.

Storage and Transfer Dewar

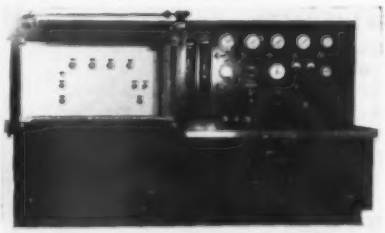
Model: LOX 150
Mfr.: Ronan and Kunzl, Inc.
Weight: 890 lbs.
Size: L-8', W-4', H-4'

Liquefied gas storage and transfer dewar used to supply liquefied gas propellants for many missiles.

Circle No. 51 on Reader Service Card, page 155, for more information.

Pneumatic Test Stand

Model: CVA-1-PNEU
Mfr.: Greer Hydraulics, Inc.
Size: L-133", W-43½", H-77"



Used to test accessories at pressures up to 5000 psi and 30 cfm flow. Compressor driven by 30 hp induction motor. Flow circuit can measure flows up to 63 cfm at atmospheric pressure. Leakage circuit can measure up to 30 milliliters. Electrical system includes operation on 400-volt 3-phase 60-cycle a-c power and provision of 110-volt single-phase 60-cycle current for test equipment. Regulated 18-30 volts d-c provided.

Circle No. 114 on Reader Service Card, page 155, for more information.

for

HIGH TEMPERATURE PROTECTION

connect with cannon!

At aircraft firewalls... and wherever high temperatures are involved... you can get protection by using Cannon Steel Shell High Temperature Connectors to protect your electrical circuits.

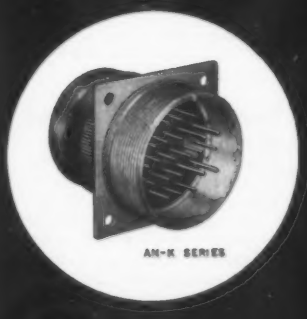
Cannon made the first multi-contact firewall and high-temperature connectors... and is still the leader in the field with the greatest variety of fireproof connectors available today.

Cannon Fireproof AN-"K" Connectors effectively block dangerous fire paths by preventing passage of open flame at 2000° F. for at least 20 minutes... and maintain electrical circuitry during that time to meet military specifications.

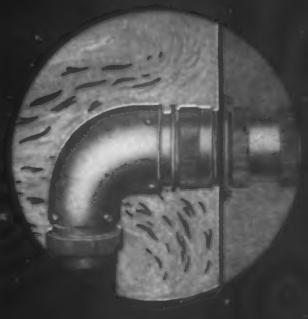
Other Cannon firewall type connectors... the AN-"FW" and K-"FW"... block fire paths for 5 minutes at 2000° F., but circuitry is not necessarily maintained. A third application, not designed for firewall use, withstands 500° F. continuous heat and maintains circuitry. Hermetically sealed connectors are adaptable to this application.

Cannon High Temperature Steel Shell Connectors are used in general industrial applications. Combinations of various parts can be made to suit many high temperature applications. Inserts of glass-filled or asbestos-filled material. Wall- or box-mounting receptacles. Straight or angle 90° plugs. Solderless crimp-on contacts available. Consult our factory, giving temperature and circuit requirements.

K-FW Series



AN-K SERIES



first in connectors

CANNON PLUGS

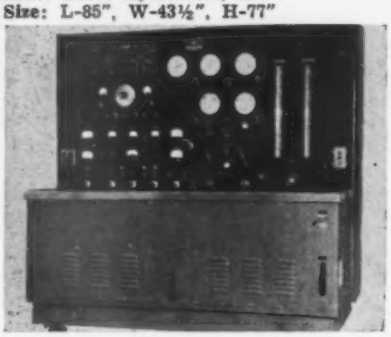
Please refer to Dept. 404

CANNON ELECTRIC COMPANY, 3209 Humboldt Street, Los Angeles 31, California

Factories in Los Angeles, East Haven, Toronto, Canada, London, England Representatives and distributors in all principal cities.

Valve Test Stand

Model: SVM-900
Mfr.: Greer Hydraulics, Inc.
Size: L-85", W-43½", H-77"



Combines electronic and hydraulic equipment for complete functional tests of Moog Series 900, two-stage servo valve, as a component or as part of a missile control system. Hydraulic circuit includes 3000 psi, 5 gpm pump. DuMont oscilloscope provided with "Servoscope" for phase lag and frequency response tests. Covers dynamic frequency response, insulation proof, current proof, and hydraulic flow tests.

Circle No. 23 on Reader Service Card, page 155, for more information.

Dry Air Stand

Model: KC-231
Mfr.: Kahn and Co.
Weight: 950 lbs.
Size: L-66", W-37", H-52"

Operating on 220-volt 3-phase 60-cycle a-c, the Model KC-231 pumps 15.3 cubic feet free air per minute at 3500 psi. Can be supplied with dehydration equipment to lower dew-point to —67°F.

Circle No. 112 on Reader Service Card, page 155, for more information.

Generator Test Stand

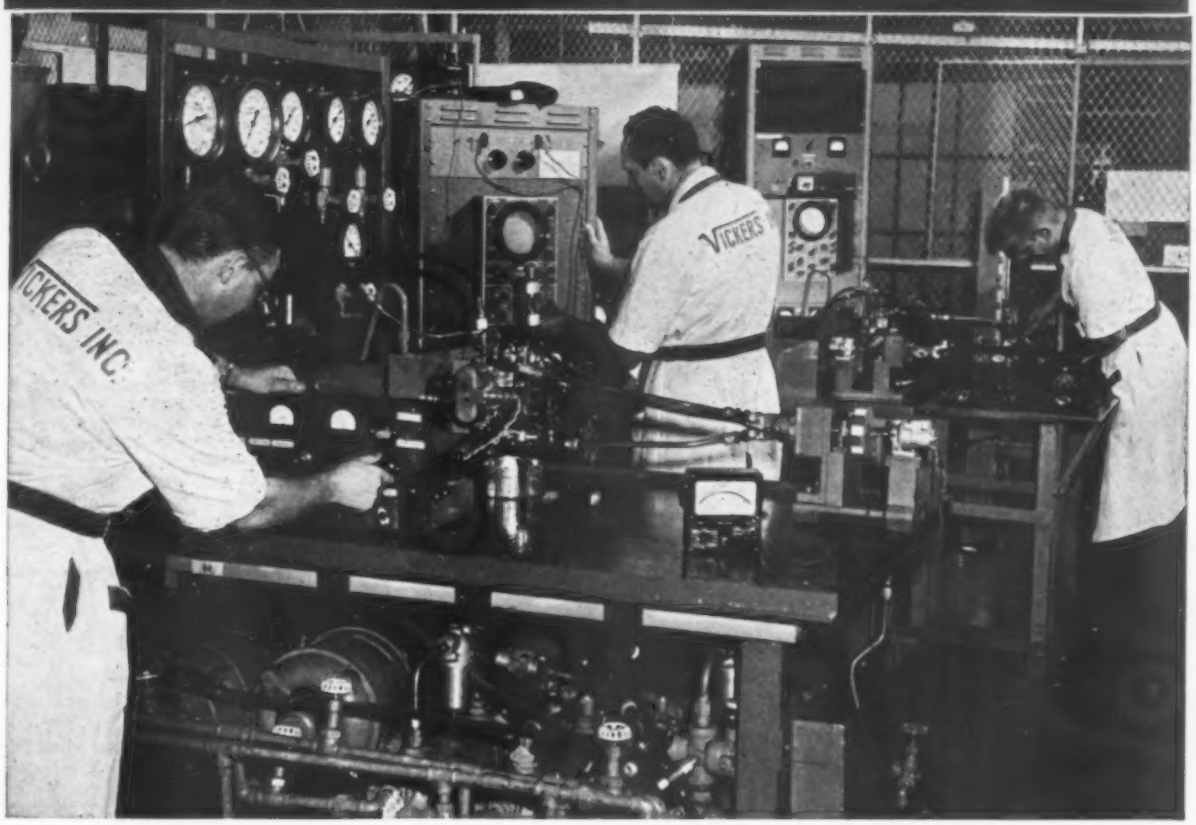
Model: MDS, Type 25
Mfr.: United Mfg. Co.
Weight: 2200 lbs.
Size: L-92", W-36", H-42"

A variable speed output missile generator test stand with a range of 4000 to 20,000 rpm delivers 25 hp on a continuous duty basis over the range from 10,000 to 20,000 rpm.

Circle No. 76 on Reader Service Card, page 155, for more information.

ONE OF A SERIES

You Get Many Benefits by Specifying VICKERS® Hydraulics



Research | that means improved oil hydraulic equipment

The list of pioneering developments in hydraulics contributed by Vickers research is long and impressive. Among the most important are:

Hydrostatic Relief Valve • Commercial Power Steering • Balanced Vane Type Pump • Flow Control Compensator • Axial Piston Pump and Motor

These are fundamental developments that have been of vital importance in the progress of hydraulics. They are representative of a large line of equipment that, with Vickers experienced application, assures you the best in any type of hydraulic operation. Vickers, with unmatched laboratory and basic research facilities, continues to lead the way in the oil hydraulics industry.

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Additional service facilities at: Miami Springs, Florida, 641 De Soto Drive

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Power Unit

Model: 2100
Mfr.: Consolidated Diesel Electric Corp.
Weight: 6200 lbs.
Size: L-132", W-65", H-90"

A self-propelled, multi-purpose power unit for electric and hydraulic testing. Prime mover is 155-hp 317-cubic inch V-8 engine driving all electrical and hydraulic components through the transmission. Electrical includes two industrial generators rated at 500 amps continuous, 28.5 volts d-c with close voltage regulation and 30 kva, .75 power factor, at 115/200-volt 3-phase 4-wire 400-cycle, or 10-kva, .9-power factor, 115-volt single-phase a-c power.

Hydraulic system uses pressure compensating variable volume pump rated at 10 gpm at 2400 psi and max. pressure 3000 psi.

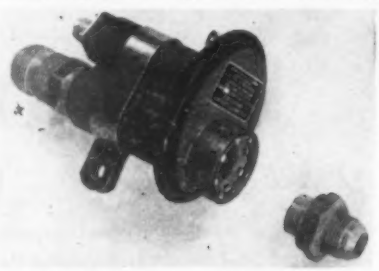
Circle No. 82 on Reader Service Card, page 155, for more information.

HARDWARE

Remote Control Coupling

Mfr.: E. B. Wiggins Oil Tool Co.

For disconnecting fluid and electrical couplings from a missile when launching. Units have been developed for operation by electric solenoid,



hydraulic or pneumatic pressure, or lanyard. Solenoid and pressure operated couplings can also be operated by manual trigger. Examples of fluid line applications include liquid oxygen, alcohol, ammonia, fuel, and hydraulic fluid.

Circle No. 33 on Reader Service Card, page 155, for more information.

Gas Sensing Amplifier

Model: CR6001
Mfr.: Marquardt Aircraft Co.
Size: L-5.75", W-3"

A mechanical hot gas temperature sensing device said to have a response rate comparable to thermocouples. Accuracy is within 2% from 900° to 1800°F.

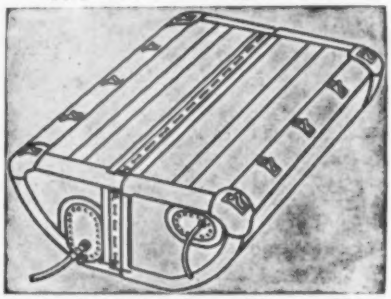
Circle No. 10 on Reader Service Card, page 155, for more information.


Hottest Fight in Design Today: Wing Shapes
New GCA Units for Expanding Navy Program
Getting the Most From the Corporate Fl
Interview
with
George F. Chapline
General Manager
Fairchild Engine Division
Fairchild Engine
and Airplane Co.
Designing Jets
For
Simpler Production
GROWTH OF AIRBORNE ELECTRIC POWER
MEDIUM BOMBARDMENT & TRANSPORT AIRCRAFT
The A-C Power System Comes of Age
Report on Tinkertoy Production Techniqu
...it all adds up
to
industry-leading editorial coverage!
One indication, and a good one we think, of the editorial acceptance and careful readership of a publication is the number of editorial reprints ordered each year by its readers.
During 1953 more than 50,000 reprints of editorial material were ordered from American Aviation.
American Aviation
Editorial Offices:
1025 Vermont Ave., N.W.,
Washington, D. C.
Advertising Offices:
LaGuardia Airport, N. Y., N. Y.
Link Expansion Ahead; Simulators Bo
Heat-Resistant Runway Material Developed
New Accessories Spur Pneumatics Growth
Executive Cabin Controls Developed
Turbine Boosts 'Copter Performance
Profile of Multi-Million Dollar Market

Fuel Cell

Mfr.: Chance Vought Aircraft, Inc.

A lightweight fuel cell developed for the Regulus missile uses jet engine bleed-air instead of a fuel pump to supply fuel to the engine. Two cells



are laced together with a rubberized fabric fuel cell collapsed by pumping air at 15 psi into the secondary bladder. Installation on Regulus resulted in 25 lb. weight-saving by elimination of three fuel pumps.

Circle No. 50 on Reader Service Card, page 155, for more information.

Pneumatic Reservoir

Mfr.: Walter Kidde & Co., Inc.
Weight: 34 lbs.
Size: L-29", Dia.-7¾"

A high temperature (300°F) pneumatic installation for in-flight actuaction of components such as rocket booster ejectors. Rated at 1000 cu. in. air at 3000 psi.

Circle No. 14 on Reader Service Card, page 155, for more information.

Reduction Gear Box

Model: 1725D3
Mfr.: Western Gear Works
Weight: 3 lbs.
Size: L-3⅛", Dia.-4"

A gas turbine driven reduction gear box for driving a guided missile alternator operates from a 24,000 rpm input with a 6000 rpm output. Unit is rated at 2½ hp.

Circle No. 115 on Reader Service Card, page 155, for more information.

Ground Connector

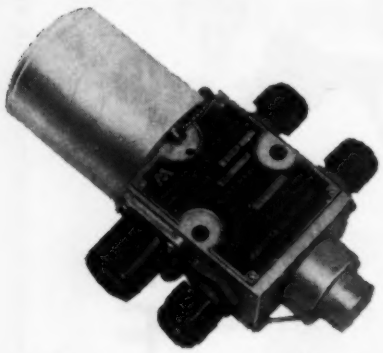
Model: A2S145
Mfr.: Burndy Engineering Co., Inc.
Weight: 2½ oz.
Size: L-2½", W-1-5/16", H-1½"

Used in ground handling equipment for the Nike missile, the Burndy Crablok connector accommodates 20 wires in sizes from 22 to 12. Wires are terminated in crimp contact tips which slip in or out of sockets in Crablok for quick circuit changes. Tips are locked into sockets to prevent opening due to tension or vibration.

Circle No. 8 on Reader Service Card, page 155, for more information.

Magnetic Valve

Model: MV-43A
Mfr.: Marotta Valve Corp.
Weight: 1⅛ lbs.
Size: L-5", Dia.-1⅝"



A 3-way normally closed valve for use with white fuming nitric acid missile propellant is rated for 3000 psi operation. Valve operates from 14-32 volt d-c current and is designed for ¼" line installation. Special seals are used for operation with nitric acid and valve is rated at .23 lbs./water per second at a 50 psi pressure drop.

Circle No. 47 on Reader Service Card, page 155, for more information.

Magnetic Valve

Model: MV-36A
Mfr.: Marotta Valve Corp.
Weight: 1¼ lbs.
Size: L-6¼", Dia.-1⅜"

A pneumatically controlled 2-way, normally closed valve rated for 3000 psi operation in both a Fairchild and Chrysler-built missile. Features extreme light weight for 2" OD line installation. Capacity is 1.39 lbs./water per second at 9 psi drop.

Circle No. 120 on Reader Service Card, page 155, for more information.

Acid Shut-Off Valve

Model: 43-1000
Mfr.: Revere Instrument Co.
Size: L-7", W-1⅜", H-1¾"

Used to control flow of red fuming nitric acid, the Model 43-1000 valve is rated for 5 lb. per second flow at 30 psi pressure drop. Normal operating pressure is 50 psi and proof pressure 1500 psi. Valve construction features use of carpenter .20 stainless steel or teflon where in contact with acid.

Circle No. 101 on Reader Service Card, page 155, for more information.

Air Compressor

Model: RG-10090-A
Mfr.: Lear, Inc.-Lear-Romec Div.
Weight: 8.4 lb.
Size: L-8-7/32", W-8", H-4-3/16"

An electric-motor-driven air compressor for pressurizing a missile built by North American Aviation, Inc. Unit operates from 115-volt 3-phase 400-cycle input and has a 34" hg absolute discharge. Inlet port has a silica gel dehydrator to dehumidify air to insure moisture free discharge.

Circle No. 96 on Reader Service Card, page 155, for more information.

High Temperature Filter

Model: 12863-1
Mfr.: Cuno Engineering Corp.
Size: L-8", W-2¾", H-3 1/16"

An 8 gpm filter of porous stainless steel construction is used in a North American Aviation missile. Construction is designed to withstand corrosive, nonflammable fluids at temperatures of 500-600°F.

Circle No. 83 on Reader Service Card, page 155, for more information.

High Temperature Filter

Model: 12848-1
Mfr.: Cuno Engineering Corp.
Weight: .7 lbs.
Size: L-4", Dia.-1¼"

Used in hydraulic servos of missile guidance systems, this filter combines a 10 micron filter of porous iron material with magnets to remove 0.10" micron iron silt particles. Rating is ½ gpm.

Circle No. 81 on Reader Service Card, page 155, for more information.

Reduction Gear Box

Model: 1790D2
Mfr.: Western Gear Works
Weight: 3 lbs.
Size: L-5⅜", W-4¼", H-4⅛"

A gas-turbine-powered drive for a missile hydraulic pump operates from a 40,000 rpm input with a 10,000 rpm output. Rated at 4¼ hp, the drive short-life requirement permits use of dry lubricant.

Circle No. 63 on Reader Service Card, page 155, for more information.

Control Valve

Model: PV-24
Mfr.: Marotta Valve Corp.
Weight: 5 lbs.
Size: L-5¼", W-3½", H-7¼"

A pressure-operated liquid oxygen control valve rated for 1000 psi operation and used in a General Electric missile. It is a 2-way, 2-position, normally closed valve design for 2" OD line installation.

Circle No. 26 on Reader Service Card, page 155, for more information.

Accessory Drive

Model: 1765R2
Mfr.: Western Gear Works
Weight: 31 lbs.
Size: L-10", W-14", H-12"

A turbine-driven accessory drive for a large missile auxiliary power plant operates from a 76,696 rpm input and provides five output pads at various speeds.

Circle No. 38 on Reader Service Card, page 155, for more information.

MISCELLANEOUS

Relief Valve

Model: R-341
Mfr.: Bobrick Mfg. Corp.
Weight: 0.3 lbs.
Size: Dia.-1", L-4"

Relief valve for high pressure nitrogen systems, set to 3500 psi.

Circle No. 15 on Reader Service Card, page 155, for more information.

J. F. Mandrow (left) and T. W. Connolly prepare a problem in dynamic analysis of an interceptor fire control system for solution on analog computing equipment.

B. D. McVey (foreground) and E. Foxman examine operation of interceptor fire control system with equipment simulating in-flight performance of target, fire control system, and interceptor.

PLANNING

PERFORMANCE

In the development of advanced radar fire control systems for all-weather military aircraft, system design objectives are determined by systems engineering and analysis. To implement these objectives the next step is the detailed analysis, design, and evaluation of the individual subsystems and units.

The Avro Canada CF-100 of the RCAF is one of the all-weather interceptors equipped with Hughes radar fire control system.

At Hughes special simulation equipment is used to synthesize aircraft and system performance. The simulator provides a means for examining system performance under laboratory-controlled conditions. In the case of airborne systems such study would otherwise require hundreds of hours of expensive flight testing to achieve comparable results.

Three important aspects of this work are:

Determination of effects on over-all dynamic stability of items such as dynamic range of amplifiers, filtering included to reduce effects of noise, aerodynamic response characteristics of the aircraft, and characteristics of computers.

Evaluation of existing systems, subsystems, or units to determine degree of modification necessary in order to meet new installation or performance requirements.

Assessment of completed systems under simulated operation to establish performance before start of production. Simulator studies are correlated with actual flight tests, helping to predict in-flight performance with reduced flight testing.

SYSTEMS ENGINEERS—CIRCUIT ENGINEERS

Further advancements in the field of radar fire control are creating new positions on our Staff for engineers experienced in the fields of systems engineering and circuit design, or for those interested in entering these areas.

Assurance is required that relocation of the applicant will not cause disruption of an urgent military project.

Scientific and Engineering Staff

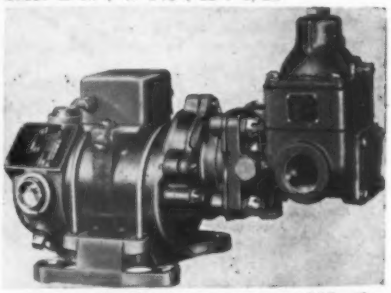
HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

Smoke Pump

Model: RD-7900-4
Mfr.: Lear, Inc.—Lear-Romec Div.
Weight: 9.5 lbs.
Size: L-11", W-3¼", H-7 1/32"



For smoke discharge system of Northrop Aircraft, Inc. missile tracking during test. Operates from 24-volt d-c current and delivers 250 gph of Texaco Corvus smoke oil and fuel mixture under 44 psi pressure to missile discharge system.

Circle No. 9 on Reader Service Card, page 155, for more information.

Isobaric Pressure Regulator

Model: 101900
Mfr.: Accessory Products Corp.
Weight: 1 lb.
Size: L-5", W-5", H-7"

Input 20—1500 psig, output 15 psia ±2. Used to maintain fixed pressure in electronic equipment housing.

Circle No. 45 on Reader Service Card, page 155, for more information.

Guillotine Chopper

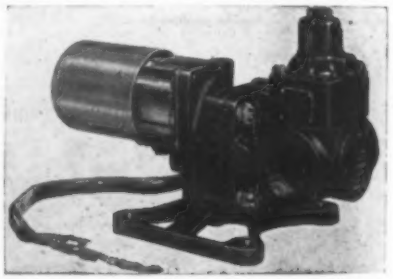
Model: 174-5-A-1, 209-1
Mfr.: Beckman and Whitley, Inc.
Weight: 41 oz.
Size: L-6", W-2", H-2"

Designed to sever bundles of cables 1½" x 2½" or fluid lines up to 1½" dia. An explosive driven device for destruction of missiles in flight, it is fired by a specific signal from a command radio. A model 209-1 weighs 20 oz. and handles 7/16" OD conductor cables with a ⅛" steel cable core.

Circle No. 38 on Reader Service Card, page 155, for more information.

Smoke Pump

Model: RG-8890
Mfr.: Lear, Inc.—Lear-Romec Div.
Weight: 5.25 lbs.
Size: L-9-3/32", W-4-13/32", H-5-11/16"



Operates on 200 volts a-c, 3-phase, 400-cycle. Pumps 110 gallons per hour of oil and fuel into missiles smoke discharge system to ease tracking job.

Circle No. 121 on Reader Service Card, page 155, for more information.

the bulletin board

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Help Wanted

Acid Pressure Switch

Model: 6836, 6867
Mfr.: Manning, Maxwell, and Moore, Inc.
Weight: 5 oz.
Size: L-3¾", Dia.-1 17/32"

For controlling flow of nitric acid oxidizer in classified guided missiles, these pressure switches operate from 28-volt d-c power source with a 3-ampere draw.

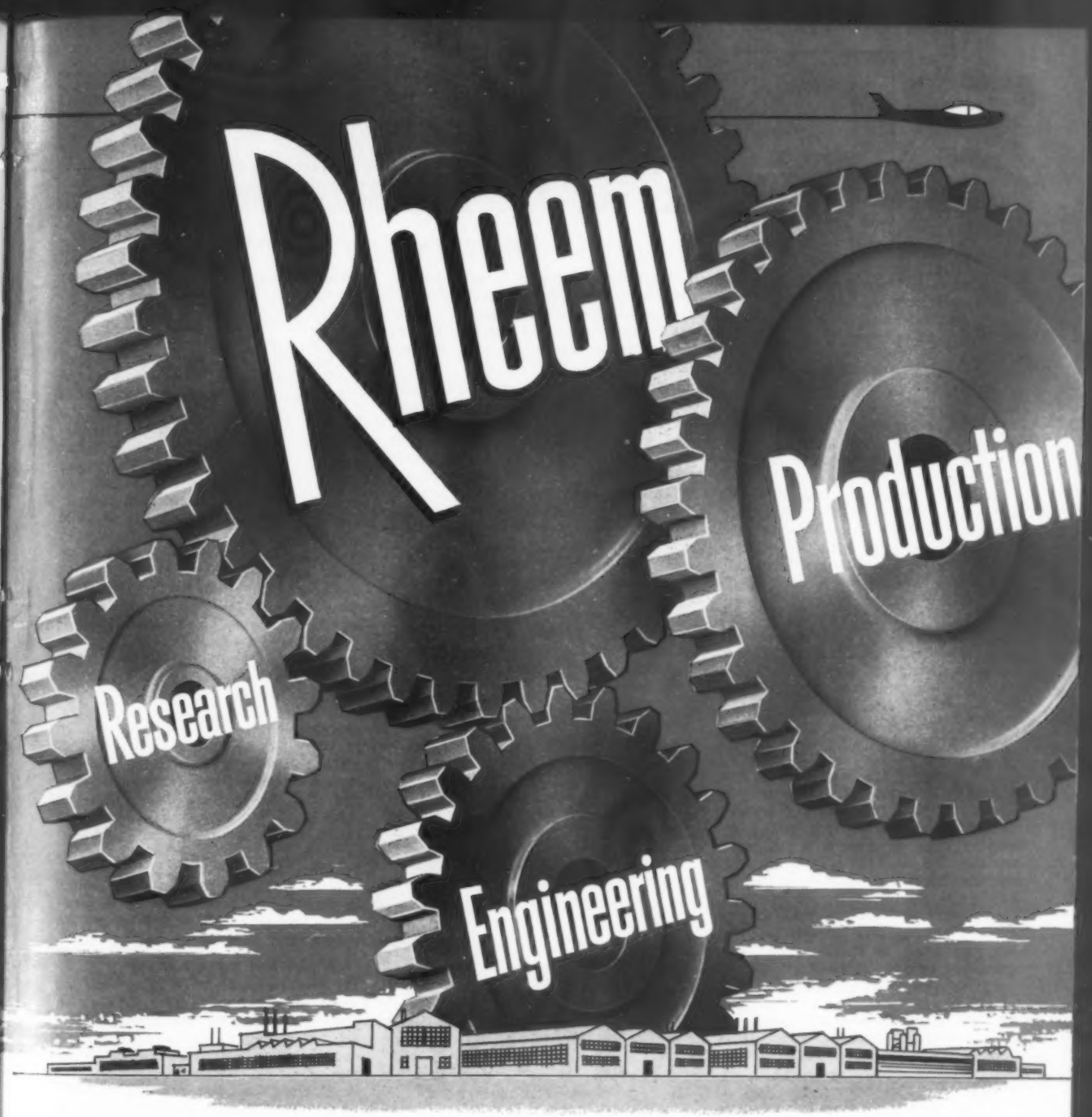
Circle No. 69 on Reader Service Card, page 155, for more information.

Barometric Switches

Model: 6870, 6864
Mfr.: Manning, Maxwell, and Moore, Inc.
Size: L-7½", W-5 11/16", H-3½", and L-8", W-6.062", H-2.3"

Manually controlled (6870) and remotely controlled (6864) barometric switches for classified missile installations.

Circle No. 118 on Reader Service Card, page 155, for more information.



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EN ROUTE . . .

WAYNE W. PARRISH

Jottings from my notebook

HERE are jottings from my notebook on the motor trip through Spain:

There are no people on the face of this earth more friendly to tourists, especially American tourists, than the Spanish. In some 4000 miles of motoring during one month I found nothing but smiles, willingness to be of help, even an anxiety to be of service. This was true when I toured the country by third-class rail over 20 years ago. It's true today.

Not only that, but there were only two isolated instances of attempts to take advantage of us as tourists. One was at Avila when I filled up with gas and I gave the attendant a large bill. He gave me change for a smaller bill. When I pointed this out in my lousy Spanish, he hastily found the big bill and pretended it was all a mistake. He wasn't a slick operator and his amateur actions were all too obvious.

The other who tried was a guard at the house of the famous painter El Greco in Toledo. The guard insisted on showing us through the place, although his help wasn't needed and he spoke no English. When I tendered a tip to him at the end of the tour, he frowned. Not enough. Like a fool I gave him another bill. He still frowned to convey the impression that he wanted a lot more. Actually, the first tip I gave him was standard for such service. This was the only guide or guard in all of Spain whom I found trying to pull the old stuff on unsuspecting tourists (such as you find tried in France, Italy, and sometimes even in England).

Ladies of Spain

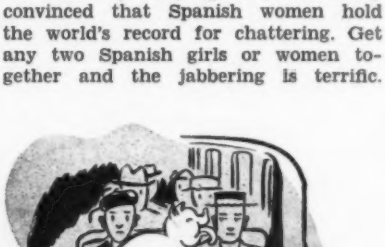
Up in northwestern Spain the peasant women commonly wear sabots, wooden shoes with pegs to keep them from slipping. Sabots are worn in various countries of Europe, especially in rural areas, but I've never seen such widespread use as in the northwestern part of Spain.

The better-class Spanish female is kept pretty much to her home except for shopping during the day and on religious or other holidays. It isn't often you see Spanish women eating in restaurants or hotel dining rooms. Except for fiestas, the average Spanish woman wears black or other very sombre clothes. This is especially true in the rural areas. In Madrid and Barcelona, of course, you find stylishly dressed Spanish women, who dine out, but the old rugged traditions are still well adhered to and that means that woman's place is in the home. If you see a well-to-do Spaniard with a fancily dressed good-looking gal, the chances are that the gal is not the wife. Like all Latins, the Spaniard continues the tradition of wife at home and mistress for amusement.

Then there's another extreme and that is the Spanish and Portuguese woman as a beast of burden. I've never seen women carry so much on their heads as they do on the western coast of Spain and in northern Portugal. Often a peasant woman is carrying a heavy load balanced precariously on her head and both hands are full, too. I saw furniture, pigs, both folded and open mattresses, big earthen urns and jars, milk cans, vegetables, fish, manure, clothing, and firewood all being carried by women on their heads. One woman carried on her head a bundle of twigs as tall as she was. And often they're barefoot, too, or wearing sabots if it's been raining.

Chattering women—and men

Before quitting Spain I was firmly convinced that Spanish women hold the world's record for chattering. Get any two Spanish girls or women together and the jabbering is terrific.



Get a half-dozen together and it sounds like a convention. Since getting back to the U. S., however, I've become aware that American women can chatter at a fast rate, too. I guess I was wrong to single out the Spanish females. Let's just face it, the female of the species everywhere jabber and chatter as if their lives depended upon it.

The Spanish men aren't exactly slackers at talking, come to think of it. Every man in Spain must spend from one to six hours a day at a sidewalk cafe, or inside if the weather isn't right. Get two Spanish gents together over coffee or sherry and they rattle along like riveters.

Parade at eventide

One feature of Spanish life, which one can also find in some parts of South America and in Yugoslavia, is the daily evening parade when an entire town seems to walk up and down the main street or a boulevard. Literally thousands will walk back and forth and the hubbub can be heard for blocks away. The gals are on display and the boys try to make friends. Men conduct business and the women do their usual type of jabbering. Back and forth they go for an hour or two at dusk and up until dinner time. It's a fascinating sight, something not to be missed in visiting Spain. You won't find the daily parade in Madrid or Barcelona, but it goes on everywhere else.

Driving at 25 miles per hour through the mountains of Galicia I had the car radio turned on to the British Broadcasting Corporation's light program. What did I hear? Music such as "Way Down South in New Orleans" while I was driving a British car with French license plates and dodging oxen and burros in northern Spain. Then, on came a cricket match and the English announcer got so excited he could only say "My goodness . . . oh my goodness" in that incredible accent which BBC announcers have. Finally he got around to describing the play. I've often wondered where in the world BBC gets its announcers; they're out of this world.

Pink pigs and steam whistles

Ever see pink pigs? If so, ever see them driven to market? There's a nursery rhyme about pigs going to market but I had never before seen pink ones being driven to market down the side of a road. But it's a common sight in Spain. The pigs are all scrubbed up for sale; then somebody buys them and drives them to the new home. Or carries them on top of a jam-packed bus. It's often a funny sight because the pig isn't exactly a trained animal for going in one direction.

Spain will be nostalgic to those of you who grew up near a U. S. railroad before the advent of the diesels. Spanish locomotives, evidently made in the U. S., have whistles like U. S. steam locomotives (like the Wabash Railroad in my case). They're quite unlike those shrill little shrieks on the French and English railroads. Now that diesels, with their unromantic bellowing, have taken over in the U. S., it was good to hear a good ordinary steam whistle again.

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55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
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